IMPROVING EQUIPMENT READINESS IN THE MARINE CORPS

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THESIS

IMPROVING EQUIPMENT READINESS
IN THE MARINE CORPS

by

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(20. ABSTRACT Continued)

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Improving Equipment Readiness in the Marine Corps

by

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Submitted in partial fulfillment of the requirements for the degree of

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from the

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December 1977

ABSTRACT

Equipment readiness is an essential component in maintaining the Marine Corps as this country's "Force in Readiness." This thesis used a survey of the logistics system operators to identify the four major improvement goals of command interest, improved training, better use of personnel and a revised stockage criteria to enhance Fleet Marine Forces equipment readiness. Managerial techniques, such as management by objectives, process analysis and variable stockage criteria, are presented as possible means of attaining the goals identified in the survey.

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I. INTRODUCTION

The first duty of a military organization is accomplishment of mission. Today's peacetime mission for the Marine Corps is readiness. Only success in today's mission will provide victory for the Navy/Marine Corps team tomorrow. It is only the ready force that will enjoy both opportunity and victory.

Readiness has three parts: men, money and materiel. Equipment readiness is the materiel-oriented blend of these three parts. Equipment readiness is a fundamental element in the development and projection of sea power. There is no rational doubt that to generate sea power equipment readiness must be included in policies, training and operations.

The reorganization of logistic support structures in the Marine Corps is well underway. The new structures incorporate the lessons of recent combat described in Ref. 1. The administrative overhead and layering of command levels of the logistic support units has been reduced by the centralization of the control of logistical units. The logistic support systems of maintenance and supply have been developed and implemented, thereby providing a common system, asset visibility and more responsive control of systems operations. The ability of the logistic systems to respond to the increased volume of business associated with combat operations has been vastly improved.

The changes in organizational structure were developed in parallel with the changes in the logistics systems. As the logistic systems developed, the planned reorganizations were implemented, thus taking advantage of the new systems such as the Marine Corps Integrated Maintenance Management System (MIMMS) and the Supported Activities Supply System (SASSY). These systems were designed to be able to accommodate the new command and control structures of the reorganization. The operators of these systems, however, continue to experience equipment readiness problems. Improvements are needed in these systems in those key areas known to and identified by the people operating the systems.

Problems identified by the men in the field cut directly to basic needs. There is an immediate return value of improved equipment readiness in identifying these needs and applying fundamental solutions. The operators know the problems, want the changes and understand the need for simple solutions. However, the day-to-day operations managers do not have the capability to do both their jobs and plan, organize, direct and control the development and implementation of the needed changes.

As a result of the new systems operating within the reorganized structure, the potentials and problems of this new relationship are being identified. After the changes needed in the system are identified, quantitative managerial techniques may be selected to correct these areas. The rapid development of quantitative managerial techniques in

the last 20 years provides a pool of technological resources from which methods for change may be selected. These methods are well known on the academic side but not well know to the day-to-day operational manager in the Fleet Marine Forces (FMF). For this reason these methods have not been applied in a combined and directed manner in the FMF.

II. BACKGROUND

A. GROUND EQUIPMENT MAINTENANCE ENVIRONMENT

The FMF has been undergoing a series of evolutionary changes in its logistic support structure and its supporting systems during the past five years. Much of this effort concentrated on corrections to deficiencies identified during the logistic rigor of the Vietnam War. Four areas of logistic management that have changed in the FMF are: the organizational structures, supply, maintenance management and the readiness reporting systems.

Organizational structures have undergone a change designed to shape the Tables of Organization (T/O's) more around the combat, combat support and combat service support structures as described in Ref. 2. Figure 1 outlines the common structures that have evolved. The consolidation of logistic support into modularized service support elements is characteristic of the reorganizational emphasis on equipment readiness support.

The organizational emphasis on the centralization of logistic efforts is supported by the use of automated data systems for the processing of supply, maintenance and readiness evaluation data. The centralized logistic units of the FMF are more capable of coordinating these multiple information systems than were the decentralized structures.

Maintenance management information has been centralized within the logistic units. The logistic units depicted in

Marine Amphibious Force
(MAF)

- Division (Ground)
- Wing (Air)
- Force Service Support Group (Logistics)

Marine Amphibious Brigade
(MAB)

- Regiment (Ground)
- Group (Air)
- Logistics Support Group (Logistics)

Marine Amphibious Unit
(MAU)

- Battalion (Ground)
- Squadron (Air)
- Logistics Support Unit (Logistics)

Three Basic Organizational Structures for the FMF

Figure 1

Figure 1 correlate and report information to using units, major commands and Headquarters level organizations. The information consists of supply, maintenance operations, equipment readiness and historical data relating to equipment maintenance. Figure 2 shows the MAF structure and relationships involved in maintenance management under MIMMS.

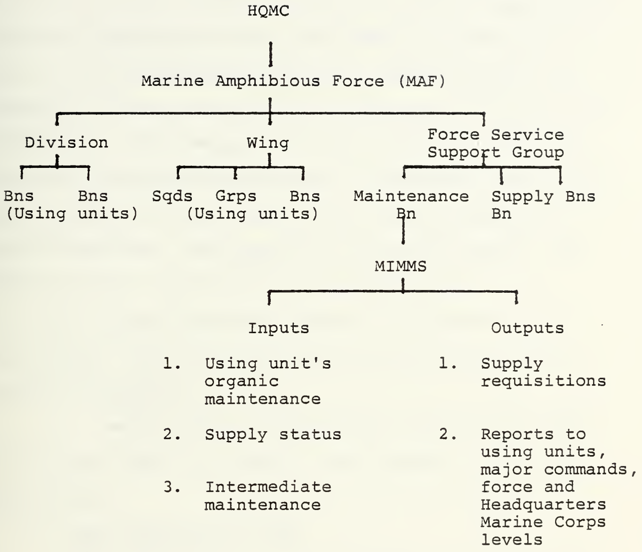
B. MAINTENANCE SUPPORT STRUCTURE

Maintenance consists of those actions required to retain or restore equipment to a serviceable condition. Commonly included in this description of maintenance are inspection, testing, servicing, repair, replacement, rebuilding, serviceability classifications and reclamation.

Maintenance services in the Marine Corps are governed by the logistic capabilities of the individual organizations. The Tables of Organization define for each organization their logistic capabilities. Three major categories of maintenance are divided into five echelons of maintenance to further define the maintenance capabilities of organizations. The echelons define the time, tools, equipment, parts and personnel available, authorized and required for a maintenance function. The official description of the maintenance structure in Ref. 3 is summarized in the following paragraphs.

1. <u>Organizational Maintenance Level</u>

Maintenance performed, authorized and within the responsibility of an organization on its own equipment is



MIMMS Structure and Overview within an MAF

Figure 2

categorized as organizational. Two major types of maintenance actions performed at the organizational and field maintenance levels are preventive and corrective maintenance. Preventive Maintenance (PM) is the effort to prevent or detect incipient equipment failures. Early detection is intended to reduce the downtime of equipment and improve its performance. Requirements for PM are focused at the first and second echelons of maintenance. Corrective Maintenance (CM) consists of those actions which repair, replace or adjust assemblies, subassemblies or defective parts. Two echelons within organizational maintenance are:

a. First Echelon Maintenance - preventive care and cleaning, lubrication and minor testing repair done by the user or operator.

b. Second Echelon Maintenance - actions performed by a trained member provided for that purpose in the using organization.

2. Field Maintenance Level

Field Maintenance is that performed and authorized by specifically designated organizations in direct support of using organizations. Repaired items from this level are returned to the user. Two echelons within field maintenance are:

a. Third Echelon Maintenance - actions performed by specially trained units in direct support to multiple using units. Select individual using units may, due to the peculiar and limited nature of some equipment, be authorized

to perform their own third echelon repair. This echelon consists of part or module-type replacement.

b. Fourth Echelon Maintenance - actions performed by specially trained personnel beyond the supported using unit's capabilities. The functions performed provide for repair of assemblies and subassemblies.

3. Depot Maintenance Level

Depot maintenance is the fifth echelon and is the repair of materiel that requires major overhaul or rebuild. Equipment repaired is returned to stock rather than to the user.

C. SUPPLY SUPPORT STRUCTURE

1. Historical Operations

Unit, major command and task unit organizations have undergone a continuous evolution in adapting to new tactics and weaponry. The supply support process of these organizations has undergone two major changes since World War II. The first was from an all manual, multiple item requisition process to a single item requisition process which remained manual at the organic account level but was mechanized to an off-set punch card process at the service support level. The second change was to a central computerized process in each service unit and eliminated the manual record-keeping process in the organic units.

The transition to a centralized process was not accompanied by a major stockage policy change. The policy

developed for expedient manual processing has continued through this evolution into the programs of the current Supported Activities Supply System (SASSY).

2. Supply Support Under SASSY

Figure 3 depicts the position of SASSY in relation to sources of supply, the service unit and the supported using units. Management of the system is accomplished in the SASSY Management Unit (SMU) to which flow daily transaction reports for the maintenance of current asset records. Materiels flow from supply sources directly to the consuming supported using units and to the major command's general account warehouses. Excess assets are returned to the general account.[1]

Requirements originating in the supported using units are reported to the SMU. The system's programs direct shipment from the general account or pass the requirement to the appropriate external sources. Receipts of assets are reported to the SMU along with issues and adjustments. The record updating for using units is performed on a post-posting basis, while the general accounts records are maintained by pre-posting.[2] Ancillary operations such as

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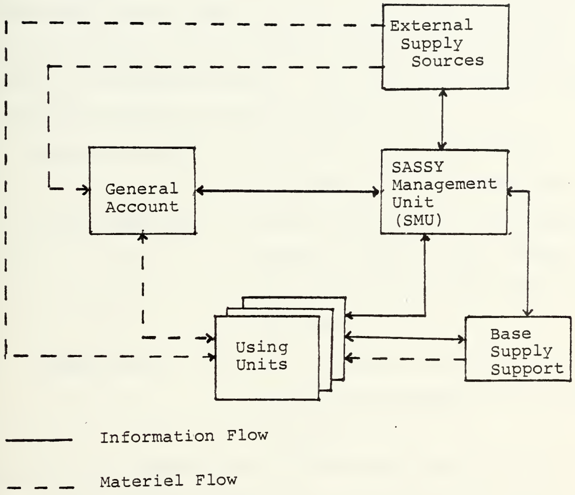
[1]U. S. Marine Corps, FMF SASSY Accounting Manual, Volume I, Marine Corps Order P4400.122A, pp. 2-3, Headquarters Marine Corps, 1976.

[2]U. S. Marine Corps, FMF SASSY Accounting Manual, Volume II, Marine Corps Order P4400.123B, pp. 2-3 thru 2-21, Headquarters Marine Corps, 1976.



SASSY Support Structure

Figure 3

stockage level computation, replenishment ordering, usage collection, reconciliation and records management are performed at the SMU.

3. Today's Stockage Policy

The criteria for the establishment of a computer-produced requisition objective (RO) and reorder point (ROP) for consumable repair parts is four or more recurring demand transactions during the past twelve month period. The RO and ROP may be computed monthly. The levels of supplies that may be authorized for the general account are:

Operating Level	-	Up to 60 days of supply for continental United States units
Order Ship Time	-	Actual time based on the average number of days to first receipt with supply source backorder time excluded[3]
Safety Level	-	Not to exceed 50 percent of the authorized operating level's days of supply.

These levels are combined for an ROP which equals the sum of order ship time and safety level and an RO which equals ROP plus operating level.[4]

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[3]Stockage policy assumes the source of supply has assets on hand and attempts to exclude source leadtime from computations. (MCO P4400.123B)

[4]Marine Corps Order P4400.123B, op. cit., pp. 6-3 through 6-5.

The current criteria of four movements in twelve months for stocking any consumable item is at present undergoing a test for possible revision. The idea being tested is to group items by unit price and have progressive sets of stockage criteria. The criteria sets are intended to make it easier to qualify a lower, rather than higher, price item for stockage and retention as a stocked item. The basic logic for this approach is that since approximately 85 percent of the parts required for repair of combat essential equipment (not operationally ready supply - NORS) have a unit price of less than $50, a more intensive stockage of these low-priced items should increase supply support performance. An increase in the supply support for NORS items is directly relateable to equipment readiness improvement. Currently the results of this policy test will not be known until April 1978.[5,6]

4. Performance Today

The accuracy of a performance measurement is often blunted by day-to-day operations which require the manager to choose less than optimal actions in order to satisfy current mission demands. However, the overall level of performance does indicate a general direction and the quality of system policies.

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[5]Lapella, Patrick J., Supply Analyst, Headquarters Marine Corps, Letter, Subject: Proposed Stockage Policy for USMC, May 1977.

[6]Schaffer, Raymond, Colonel, Head, Logistics Plans and Policies, Headquarters Marine Corps, private conversations, April 1977.

Under the current stockage policy the non-availability of items with computed RO's is depicted in Figure 4. Non-availability is that percent of the total RO items which have zero asset on hand at a specified time. Figure 4 represents the recent non-availability record for the general account in the II Marine Amphibious Force (II MAF) at Camp Lejeune.[7]

The RO item fill rate for the II MAF general account is presented in Figure 5.[8] The fill rate is the percent of times that requirements for RO items were completely satisfied from assets on hand in the general account upon initial processing of the requisitions.

Extraordinary and intensive management efforts during June and July 1977 at the II MAF SMU were able to change the July non-availability of RO items to 19.2 percent and the fill rate to 71.5 percent.[9]

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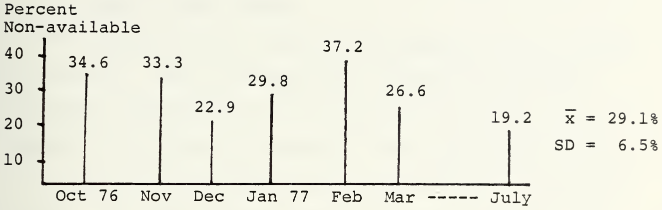
[7] II MAF SASSY Management Unit, Balance Analysis General Account Balance File Report, October 1976 thru March 1977.

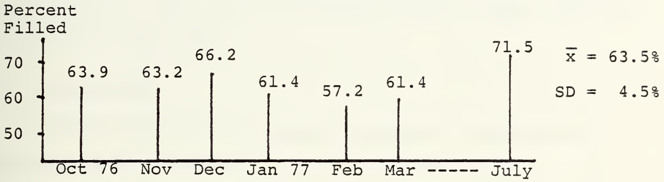
[8] II MAF SASSY Management Unit, General Account Performance Reports, October 1976 thru March 1977.

[9] Schamay, Richard, Lt. Colonel, Officer in Charge II MAF SASSY Management Unit, Camp Lejeune, private conversations, June thru September 1977.



Non-Availability of Stocked Items at II MAF

Figure 4



Stocked Item Fill Rate at II MAF

Figure 5

III. PROBLEM

A. STATEMENT OF THE PROBLEM

The ground equipment materiel management process should be improved. The improvements must consider appropriate economical constraints and be tailored to be useful to the managers in the operating forces. These improvements should not add any new requirements or workload on the operational manager. The improvements should be aimed at helping the commander resolve his equipment readiness responsibilities.

The problem statement is: Define methods for improving the ground equipment readiness of units, considering both the mission of the unit and an appropriate economic readiness posture for the units.

B. CONSTRAINTS

Methods identified to improve equipment readiness must meet three requirements. First, the technology must exist and not create any unusual financial problems which would block their use. Second, existing data bases and supporting programs must not be altered beyond simple modular replacements. Third, changes to implement the methods must not increase the workload of the field operator by requiring his work to be expanded into areas in which he is not presently involved.

C. METHODOLOGY

A survey of selected officers responsible for the operation of the logistic support system of the FMF was completed. The purpose of the survey was to identify areas of equipment readiness which the field operators believed needed improvement in order to enhance equipment readiness in the FMF. The survey was directed toward developing a general consensus among the participants on equipment readiness goals needing improvement.

An analysis of the goals was then performed to identify where quantitative managerial techniques could assist in the attainment of the goals. Two general areas for study were developed. The first dealt with improvement of the use of personnel in the logistic system. The second area dealt with identification of FMF stockage policy elements that could be adjusted to improve the policy's equipment readiness impact and the responsiveness of the supply support system.

IV. IDENTIFICATION OF GOALS TO IMPROVE EQUIPMENT READINESS

A. BACKGROUND

A survey was conducted in three phases during the period April through July 1977. Phase one was a request for the nomination of objectives to be improved; phase two was the ranking of the ten most popular objectives; finally, after having studied an analysis of the first ranking process, the participants performed a third phase for the final ranking of the ten objectives. Copies of each phase's correspondence are in Appendix A.

The officers selected to participate in the survey were picked based upon experience, knowledge of the FMF logistic system, current assignments and the author's personal assessment of their ability to be objective. The following is a rank-ordered list of the twenty-eight officers who participated in the survey:

Rank	Number
General	2
Colonel	9
Lt. Colonel	7
Major	7
Captain	3

B. PROBLEM

The problem for the survey was to identify areas of operation in the Marine Corps' logistic support system that

need improvement in order to enhance the equipment readiness of the FMF. The observation of this need was to be made by the personnel most concerned with the day-to-day operation of the logistic system.

C. IMPLEMENTATION

1. Approach

The survey of areas needing improvement in the logistic system was done by mail. The survey required the completion and return of pre-printed reply forms. Participants initially could identify three areas which each believed needed the most improvement in order to enhance equipment readiness. The subsequent rankings of objectives by the participants required the ordering of the objectives. This ordering process allowed each participant to rank all or only those objectives he believed he was competent to evaluate. Additionally, the participants were able to identify multiple objectives as being tied for a specific numerical rank, such as two objectives being tied for first place.

2. Phase One

The first requirement was for each participant to nominate three specific objectives which, in his opinion, should be accomplished in order to improve ground forces equipment readiness. Each of these objectives was to be scaled by the participant to indicate each objective's value toward improving equipment readiness.

The objectives nominated by the participants were evaluated to identify the top ten objectives on the basis

of frequency of nomination and mean value assigned by the participants. The nominated objectives were sequenced by number of replies. The degree of agreement was indicated by the mean and the standard deviation of the participant-assigned values for each reply. Appendix A's correspondence of May 1977 contains a listing of the top ten objectives and their associated histograms and data which were generated based on the replies in phase one.

The following is a listing of the top ten objectives identified during phase one:

<u>Obj. No.</u>	<u>Description</u>
1	Increase and improve Military Occupational Specialty (MOS) training for maintenance and supply personnel. Included are: a) teach mechanics how to analyze problems b) teach the skills necessary for performance c) teach managerial skills to supervisors
2	Increase command interest in materiel and maintenance management programs. Included are: a) developing dedicated personal involvement b) optimal integration of supply and maintenance resources in a command c) increased awareness of first and second echelon responsibilities
3	Increase the effective use of supply and maintenance personnel. Included are: a) maintain minimum 50 percent manning level b) require 75 percent of personnel's time to be used for supply and maintenance activities c) match equipment maintenance requirements with availability of personnel d) enhance operator pride in equipment
4	Revise the stockage criteria for repair parts to improve the demand fill rate. Included are: a) consideration for end item application b) availability at first part source greater than 75 percent c) use of economic order quantites

5	Increase use of all materiel assets in support of maintenance. Included are: a) use of prepositioned war reserve materiel (mountout) for high priority Not Operational Ready-Supply (NORS) b) greater use of Operational Readiness Float assets and the Replacement and Evacuation programs c) use of a peacetime loan pool to reduce equipment turbulence in loaning units
6	Increase the use of maintenance engineering analysis to improve poor performance parts. Included are: a) use of "reverse engineering" b) use of more accurate replace versus repair criteria
7	Increase the effective use of equipment. Included are: a) limit equipment use to field operations, deployment and training b) store non-used Table of Equipment items in a Marine Corps Logistic Support Base maintenance program
8	Increase supply system responsiveness. Included are: a) more correct and timely requisitioning b) more intensive SMU management of accounts and items c) centralized repair part support at Force Service Support Group
9	Better match of funding with requirements. Included are: a) adequate funding for stockage criteria b) units funded to cover repairs
10	Improve equipment specifications and acceptance test in the acquisition process. Included are: a) emphasis on maintainability b) emphasis on supportability

3. Phase Two

The results of phase one, both the listing of the top ten objectives and their statistical analysis, were provided as goals to each participant. The participants were requested

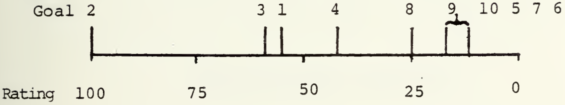
to evaluate these goals considering their original ideas and the opinions of others as reflected in the top ten listing and statistics.

Phase two obtained rankings from the participants of the relative importance of each goal. The objective of phase two was to develop for the participants, from their rankings, a scaled quantitative position listing of the goals. This was done by using programs developed and described in Ref. 11 as a variation of the Ford procedure. This procedure allows for increased validity in rankings by allowing each participant to rank only those goals which he believed he was confident to judge and to include ties between goals that he believed had the same rank. Figure 6 is the scaled preference chart produced by using the Ford procedure programs on phase two rankings.

The command interest objective was assigned 100 and the other objectives were scaled in relation to this top objective. The resultant diagram in Figure 6 provides a composite interval ranking of objectives based on the opinions of all the participants.

Table 1 is a Win/Loss Matrix of the goals. The rows of the matrix indicate the number of times the row goal was considered more important than each column goal. Conversely, the columns indicate the number of times the column goal was considered less important than the row goal. The matrix data shows the preference and non-preference between individual goals based on the sum of all comparisons made by

Goal	Definition	Rating
1	Improved training	56.2
2	Command interest	100.0
3	Use of personnel	59.6
4	Revised stockage criteria	43.8
5	Maximize use of materiel assets	16.8
6	Improve maintenance engineering analysis	12.8
7	Maximize effective use of equipment	15.6
8	Supply responsiveness	26.0
9	Better funding	17.7
10	Improve equipment specifications	15.8



Phase Two Preference Chart

Figure 6

R/c	2	1	3	7	10	9	4	8	5	6	Sum Wins	Percent Won
2	0	14	16	21	19	20	12	17	19	18	156	81.3
1	6	0	10	18	19	15	11	15	17	18	129	65.5
3	5	8	0	19	17	15	12	17	17	15	125	66.1
7	1	4	3	0	13	10	7	8	6	10	62	32.8
10	4	5	5	10	0	13	8	7	9	9	70	35.9
9	1	9	8	12	10	0	6	9	11	10	76	39.2
4	9	11	10	14	13	16	0	11	18	14	116	62.0
8	4	7	5	13	14	7	6	0	15	14	85	47.0
5	3	7	4	13	13	12	5	6	0	12	75	38.3
6	3	3	3	7	7	10	4	6	9	0	52	30.2
Sum Losses	36	68	64	127	125	118	71	96	121	120	946	

Phase Two Win/Loss Matrix

Table 1

the participants. These individual goal comparisons generally support the ratings shown on the scaled preference relationships of the goals in Figure 6.

The rankings of the participants in phase two were correlated by participant seniority. Four classes of participants were developed:

1. All
2. Generals and Colonels
3. Lt. Colonels
4. Majors and Captains

The matrix of Pearson Correlation Coefficients that was produced by the SPSS programs is in Table 2. The matrix demonstrates the degree of agreement between each of the different participant class rankings of the goals. The matrix shows both the correlation coefficients and their associated levels of significance. Table 2 demonstrates a decrease of correlation between the class rankings as seniority decreases.

The overall assessment of phase two is that the main area needing improvement related to people. The top three goals require an improvement in command interest, more effective use of personnel and improvement in occupational training of personnel. The next two goals dealt with the materiel side of the logistic system calling for improved stockage criteria and increased supply system responsiveness.

	All	Gen/Col	Lt. Col	Maj/Cpt
All	C = 1.0000	C = 0.9257	C = 0.8945	C = 0.8321
	S = 0.001	S = 0.001	S = 0.001	S = 0.001
Gen/Col	C = 0.9257	C = 1.0000	C = 0.8139	C = 0.6635
	S = 0.001	S = 0.001	S = 0.002	S = 0.018
Lt. Col	C = 0.8945	C = 0.8139	C = 1.0000	C = 0.5474
	S = 0.001	S = 0.002	S = 0.001	S = 0.051
Maj/Cpt	C = 0.8321	C = 0.6635	C = 0.5474	C = 1.0000
	S = 0.001	S = 0.018	S - 0.051	S = 0.001

* C = correlation, S = significance

Phase Two Pearson Correlation Coefficients Matrix

Table 2

4. Phase Three

The scaled listing of goals in phase two was provided to the participants. They were again requested to evaluate these goals, giving consideration to their prior rankings, their continuing opinions and the composite ranking data from all other participants.

The objective of phase three was to act as a "conventional Delphi" where the participants have an opportunity to re-evaluate their initial responses after reviewing the combined replies of all the other participants.[10] The intent of this process was, by a regulated and rational review of the iterated ideas in phases one and two, to develop a convergence of the opinions of the logistic system operators on the areas that needed improvement.[11]

Figure 7 is the comparison of scaled preference charts from phases two and three. It demonstrates both a continued general ordinal relationship of goals between the phases and an increased spatial relationship showing convergence of the participants on the dominant goal.

The charts in Figure 8 exhibit the impact of the Delphi on each of the ten goals. The goals are displayed in scaled preference within the seniority classes for both

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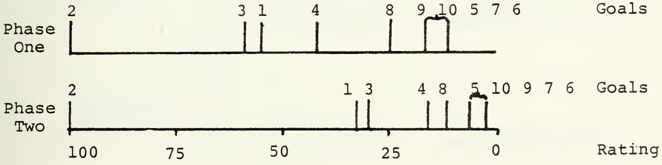
[10] Linstone, Harold A., The Delphi Method; Techniques and Applications, pp. 5-10, Addison-Wesley, 1975.

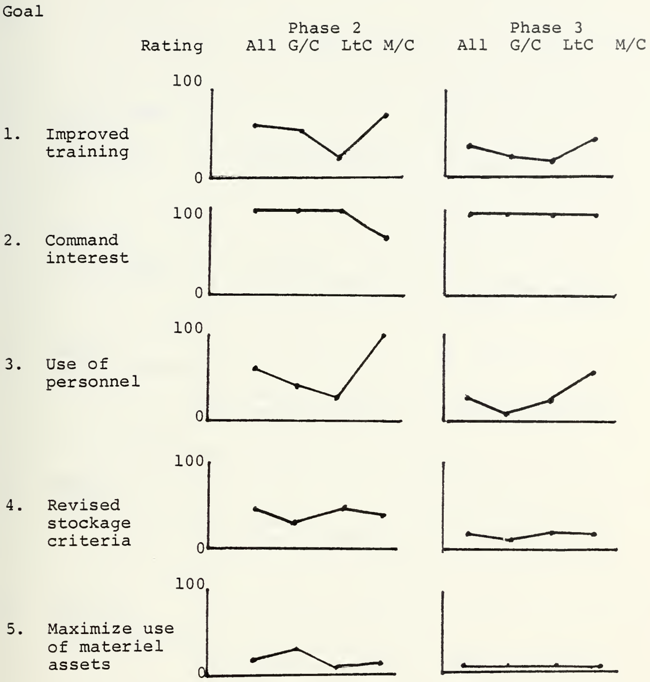
[11] Sackman, Harold, Delphi Critique, pp. 8-10, D. C. Heath and Co., 1975.

Goal	Definition	Ratings Phase One	Ratings Phase Two
1	Improved training	56.2	32.8
2	Command interest	100.0	100.0
3	Use of personnel	59.6	31.1
4	Revised stockage criteria	43.8	17.3
5	Maximize use of materiel assets	16.8	07.0
6	Improve maintenance engineering analysis	12.8	03.5
7	Maximize effective use of equipment	15.6	04.7
8	Supply responsiveness	26.0	13.0
9	Better funding	17.7	04.8
10	Improve equipment specifications	15.8	05.1



Comparison of Phases Two and Three
Preference Charts

Figure 7



Impact of Delphi on Individual Goals

Figure 8

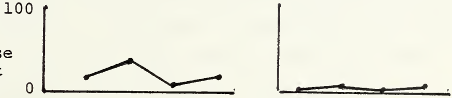
Goal

Phase 2 — Rating: All, G/C, LtC, M/C

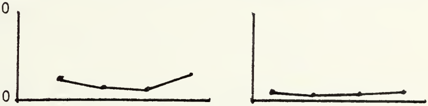
Phase 3 — All, G/C, LtC, M/C

6. Improve maintenance engineering analysis

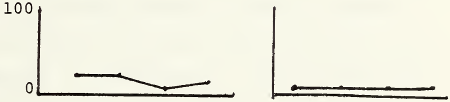
7. Maximize effective use of equipment



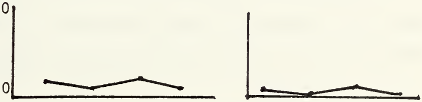
8. Supply responsiveness



9. Better funding



10. Improve equipment specifications



phase two and phase three. The charts depict the participants' convergence of opinion on goal 2. In summary, these charts show a smoothing of differences between seniority classes from phase two to phase three. A general decrease is shown in the scaled preference for the non-dominant goals.

The above observations are supported by the matrix of Pearson Correlation Coefficients produced by SPSS programs and presented in Table 3. The matrix demonstrates the higher agreement of each seniority class ranking with each other class ranking than that which resulted from the phase two correlation in Table 2.

D. CRITIQUE

A criticism of the approach used is that there was no discounting done on the participants' current judgments and opinions, even though the goals they identified could only be used sometime in the future.[12] Since uncertainty increases the further ahead that planning is projected, care should be taken in using the goals to assess the impact of the use of any short planning horizon on the part of the participants.

The tendency to over-simplify was enhanced in this approach by the compressing of ideas into brief statements and by the grouping of similar ideas into a common statement, both

[12] Linstone, op. cit., pp. 574-577.

	All	Gen/Col	Lt. Col	Maj/Cpt
All	C = 1.000	C = 0.9837	C = 0.9915	C = 0.9509
	S = 0.001	S = 0.001	S = 0.001	S = 0.001
Gen/Col	C = 0.9837	C = 1.000	C = 0.9837	C = 0.8825
	S = 0.001	S = 0.001	S = 0.001	S = 0.001
Lt. Col	C = 0.9915	C = 0.9837	C = 1.0000	C = 0.9200
	S = 0.001	S = 0.001	S = 0.001	S = 0.001
Maj/Cpt	C = 0.9509	C = 0.8825	C = 0.9200	C = 1.0000
	S = 0.001	S = 0.001	S = 0.001	S = 0.001

* C = Correlation, S = Significance

Phase Three Pearson Correlation Coefficients Matrix

Table 3

of which have associated communication losses.[13] These were identified in participant notes on ranking replies. First, a couple of goals, such as eight and ten, although they have merit, were considered as universally desirable as "motherhood" and not defined enough to be attainable. Second, the reverse occurred with goal three where a knowledge of present-day conditions of personnel "time availability" caused a rejection of a specified 75 percent availability goal, while the substitution of 60 percent in the goal would have caused the participants to have rated the goal higher.

The survey approach intended that each participant's response be free from face-to-face confrontation with other participants and not be influenced by the rank of the other participants. This was done by stressing in the first letter the desirability of private opinion which was free from pressures to conform. Additionally, the participants did not receive any seniority-related ranking information until the survey was completed. This process did not, however, exclude participants from identifying each other on their own or exchanging their opinions. The geographic distribution of the participants would have effectively limited this type of interchange and its possible swaying of the opinions of juniors by senior participants.

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[13] Sackman, op. cit., pp. 57-71.

The subjective nature of opinions, the presence of ambiguity in the goal statements and in the ranking responses, require that the data not be considered specific and concise but rather directional and trend-like in accuracy.

The survey centered upon personnel most of whom are directly responsible for providing logistic support to the FMF. As a consequence, the question of this group being able to reflect the equipment readiness needs of unit commanders, who could be considered recipients of logistic support, was evaluated. Most of the commanders included in the survey were in the colonel grouping. The nine colonels in the survey were divided into two groups: five were currently in command billets and four in logistic staff billets. The evaluation was done by determining the correlation of the responses between the groups and the degree to which this relationship between them could have occurred by chance. The final rankings of the two colonel groupings were each scaled using the Ford technique, which is described above. The scaled rankings of the two groups were then correlated using the Statistical Package for Social Sciences (SPSS) programs for Pearson Correlation Coefficients. The coefficient resulting was 0.8520 with a significance of 0.001. The significance is the risk, computed using the 'Student's t' distribution, of the correlation occurring by chance. It was concluded that there was no significant difference between the commanders' and logistic staff officers' definition of needs.

V. MANAGEMENT BY OBJECTIVES AS A MODEL

A. BACKGROUND

Command interest is an important factor in improving equipment readiness in the Fleet Marine Forces (FMF). In the above survey 16 out of 27 officers responsible for the effective operation of the FMF logistic systems nominated command interest as one of their first steps to improving the logistic system. For example, the Deputy Chief of Staff for Installations and Logistics at Headquarters Marine Corps wrote that the first step to achieving improved equipment readiness is: "To achieve and maintain the commander's dedicated personal involvement in the equipment readiness program."

Recognition of the importance of command interest extended to the survey's most junior officer who wrote: "Instill a greater devotion toward maintenance management in unit commanders - so they don't wait until the equipment is down to worry about it."

The commander of each organization is responsible for the creation of an environment that allows the unit to successfully complete its mission. The three levels of formal Marine Corps schools - Basic, Amphibious Warfare, and Command and Staff - each present and teach the use of a management model tailored to combat operations. The principles of command and the sequence of command and staff actions

are the major elements in the combat management model. However, this model was not designed to effectively manage the internal business-oriented operations of a unit but rather its combat operations.

Commanders are aware of their need to have their units' equipment in a ready state. The schools and technical publications describe both the causes and characteristics of equipment that is in poor condition. Additionally, the commanders and their staffs know the basic functions of a business manager are to plan, organize, direct, control and coordinate. The element of command interest that is not known and not taught to the commander is "how" to manage effectively the business-oriented operations of a unit. The commander is provided neither the principles nor a model to be used as a vehicle in creating an environment that promotes effective management.

B. PROBLEM

The problem statement is: What management method could be used by commanders to manage the business-oriented operations of units so that the goals of the commanders are effectively realized?

C. IMPLEMENTATION

1. Effectiveness Principles

The commander has authoritative direction over his unit and is expected to be effective in his job. The ability to get the right things done is the hallmark of an effective

commander. There are principles of command which detail general ideas that each commander should apply in performing his duty. The Marine Corps uses the following principles of command:

Assumption of Responsibility - Each commander is responsible for everything his unit does or does not do.

Delegation of Authority - Each commander must delegate authority to subordinates commensurate with their responsibilities.

Issuance of Orders - Orders to subordinates are in the name of the commander.

Chain of Command - Orders are issued to subordinate units through the subordinate commanders.

Supervision of Execution - Follow through on orders to assure timely and accurate conformance.

These principles can be related directly to such functions of a business-world manager as planning, directing, organizing, controlling, supervising and coordinating.

The above principles do not include three important factors which were identified by Drucker in Refs. 14, 15 and 16 as key elements in developing an effective manager. The factors are time, contribution and priorities. They apply to the commander who is a command resource that needs to be maximized. Careful application of these factors could enhance his effectiveness.

a. Time

The commander, as a limited resource, must know how he is currently being expended or where his time actually goes. Mentally recalling the amount of time spent on various activities each day and over several weeks is not an adequate measure of a commander's time. He must record actual time-use. The method used can be varied but the result must reflect the activity, the actual time and not be based on memory. The record of time used can be analyzed after it has been accurately recorded.

The analysis of time-use can be done in three areas. First, identify and eliminate those things that do not need to be done at all. Second, identify and delegate those things that could be done as well by somebody else. Finally, identify and eliminate the activities of the commander that waste the time of subordinates. Characteristics of activities in these areas include recurrent crisis, overstaffing, an excess of meetings and poor information flow.

The final activity relating to time-use is consolidating the time a commander has freed for his use. This discretionary time is limited and must be applied to those areas where he can make the best contribution to his organization. The effective activities of a commander require adequate time to plan, study and coordinate. The commander who can free up two-thirds of a day each week will

gain nothing if it is spread out in 10 and 15 minute blocks throughout the week. The commander must consolidate his discretionary time to use it effectively. Meetings, office hours, briefings, inspections and the other activities of the commander should be scheduled to allow for the consolidation of discretionary time.

b. Contribution

Each commander must direct himself toward the value he can add to the organization. His commitment or contribution must consider the entire organization and its purpose. The commander's efforts must be result-oriented rather than effort or work-oriented. He must want to take and be held responsible for the performance of his whole unit, not just a special section or area.

The commander has three areas to contribute to with regard to the whole organization. These areas are direct results, the creating of values and the development of people. He must contribute in each of these areas to help the organization exist today, to grow and survive tomorrow.

The direct results to be attained are usually well known; for example, to provide combat power, communications, fire support and service support. These areas have the characteristic of being essentials in the daily operation of the unit. The commander's first priority in contributing to the organization should be in the direct result area. The commander must contribute to the organization's

continuing values. Esprit and pride in performance and duties are typical areas. The commander must weigh the ambiguities in values in making his contribution to this area. For instance, he must balance physical training and military subjects training time, the performance of equipment preventive maintenance and the mission of the unit so that the value of each time demand is kept in proper perspective with the unit's mission needs.

Finally, the commander is required to contribute to the future of the organization through the development of its people. The commander must continuously enhance the ability of his people to move beyond their present-day performance levels. The commander who emphasizes the importance of each man contributing to the organization is causing his people to adjust to a higher level of demand. Communications are increased by people working to find ways to help contribute to the whole organization and not just to the smaller portion within which they work. This emphasis on contribution tends to increase lateral communications and, therefore, makes teamwork within the organization possible.

c. Priorities

The commander must concentrate his efforts. Effectiveness is enhanced by concentrating on one thing at a time. Due to his limited discretionary time the commander must focus his time on his contributions to the organization.

A commander's contributions, by their important nature, require a substantial amount of time. Additionally,

because he has so many things to do, he must concentrate his effort, resources and time in order to get a large number of his many requirements done. Effectiveness in this environment lies in the commander concentrating his time and resources on doing one task at a time and insuring that he is working on that task which makes the highest contribution to the whole organization.

The manager must assign priorities to tasks by considering several characteristics of his tasks. Tasks which relate to the future offer more opportunities than tasks that correct problems of the past and only return the organization to a previously established norm. The choice is between focusing on opportunities instead of on problems. The priority of the tasks should be based on the difference the tasks will make for the whole organization. The commander must continually reassess the priorities of his tasks after the one he has concentrated on is completed.

2. Systems Approach

The question the commander faces is how to bring about an improvement in effectiveness. He must find a method, vehicle or model which allows him to gather together his mission, unit and people. Management by objectives (MBO) is a business sector developed approach which could be used successfully by a commander.

MBO is a systematic approach to attaining goals. It's structure allows a commander to apply the above effectiveness principles. MBO has been defined by McConkey in

Ref. 17 as having the following parts:

> First, those accountable for directing the organization determine where they want to take the organization or what they want it to achieve during a particular period (establishing the overall objectives and priorities).
>
> Second, all key managerial, professional and administrative personnel are required, permitted and encouraged to contribute their maximum efforts to achieving the overall objectives.
>
> Third, the planned achievement (results) of all key personnel is blended and balanced to promote and realize the greater total results for the organization as a whole.
>
> Fourth, a control mechanism is established to monitor progress compared to objectives and feed the results back to those accountable at all levels.

The system components of MBO are the establishment of objectives, directing the attainment of objectives and monitoring results.

a. Objectives

MBO requires that objectives established by the commander give direction to the organization. These overall objectives become the framework within which the subordinate line and staff managers will develop their objectives. The participation of multiple-level managers in setting supporting objectives is discussed more fully in Refs. 17, 18 and 19. These multiple-level objectives break down, in a controlled manner, the overall objectives into manageable parts. This is done by the agreement of the subordinate managers and their commander on each subordinate's objectives.

When added together, the objectives that are agreed upon equal the overall objectives of the commander. To be effective each of the objectives must have the following characteristics:

(1) Specific - The description must clearly state the who, what and when of the objective.

(2) Attainable - The objectives must be within the authority and ability of the managers to accomplish them. The objectives should, however, require the managers to exert more than their normal effort to complete them.

(3) Result-oriented - The objectives should be a specific statement of an end result, not a description of activities to be performed by the managers.

(4) Limited to priorities - The number of objectives should be controlled to allow the managers to be able to handle them. Limiting numbers of objectives reinforces the need to evaluate and agree on the use of priority objectives.

b. Directing Attainment

Each manager's objectives must be converted to specific plans of how the objectives are to be accomplished. The plan for each objective spells out, step by step, how the manager intends to attain his objectives. The review and agreement by the commander concerning the subordinate manager's plans assures that the plans are realistic, attainable in view of available resources and in agreement with the commander's overall objectives. The plans lay

out a concrete way to measure the movement of the unit toward its goals.

After specific plans for each subordinate's objectives have been developed and approved by the commander, the managers are required to give the necessary directions and to take the proper actions to carry out his objectives. Here the managers must perform the functions of coordinating, communicating and motivating their people. Each manager must put into action the plans that he has established. It is through his directions that the objectives become reality.

c. Results

MBO establishes specific objectives and then defines the specific way they will be measured. Each goal has a measure tailored to it. The measure determines how well the goal is being attained. The controls developed for each objective are designed to inform only the manager and to provide only the information necessary for his level.

MBO gives the manager responsibility. After objectives and plans are agreed upon by the commander and his managers, each manager is responsible for the accomplishment of his objectives. The controls necessary to do this need to support the managers, not the next higher level. The result is an operational control system that is both shorter and more responsive than one that requires reports to superiors. Controls that flow through superiors decrease the responsibilities of the subordinates and cause the

commanders to spend their limited time in performing delegatable work.

James Longley, Governor of Maine, discussed in Ref. 20 the relationship between leadership and delegation of responsibility. Longley said:

> A leader must have strength and the capacity to delegate and turn his back and walk away and depend on others to implement the decision.
>
> A leader must recognize that, while every act or commission delegated might not be fulfilled completely to his satisfaction, that in all probability it might have been done better than he could do, or would have done himself, if for no other reason than he can't do everything.
>
> A leader must strive for perfection but recognize that if he waits to do anything, or complete a mission so expertly that no one, present or future, can ever find fault with it, chances are he will never accomplish the mission."

VI. USE OF BASIC PRODUCTION MANAGEMENT TECHNIQUES

A. BACKGROUND

The survey of Marine Corps personnel who operate its logistic system identified occupational training and effective use of supply and maintenance personnel as major areas needing improvement in order to enhance equipment readiness. The development of quantitative managerial techniques in the past 20 years to improve resource utilization has provided a pool of technological methods. These methods have been hard to implement in the FMF because of the day-to-day operations and concerns of the managers. However, they are the very actions which, when applied in a combined and directed manner, could improve equipment readiness. The implementation of these methods should be considered by managers as goals within the description of Chapter V. The accomplishment of the methods described below could enhance and be the managers contribution to his organization's equipment readiness goals.

The productive use of this technology would decrease the gap between actual operational efficiency and what is theoretically possible. The uncertainties of the operational environment would be both better understood and controlled by the rational application of these fundamental management techniques. The basic idea here is that there are identifiable

problems in equipment readiness in the FMF which can be resolved quickly and economically by use of simple techniques.

The relationship between using these improved techniques and equipment readiness can be seen in the definition of equipment availability. Availability is a major portion of readiness and is defined in Ref. 21 by the ratio of mean time between failure (MTBF) divided by the sum of MTBF plus mean time to repair (MTTR) plus mean supply response time (MSRT). Those techniques which improve the flow time of a job through a shop increase the availability. Techniques that identify bottlenecks in materiel, personnel or information flows, or those techniques that help concentrate efforts on priority results or improve the skills needed for effective repairs all increase the availability of equipment. In summary, techniques which result in either a shortening of the MTTR and the MSRT or in a lengthening of the MTBF will contribute to improving equipment readiness.

B. PROBLEM

The problem statement is: Are there quantitative managerial techniques that could be used to improve equipment availability? The criteria are the minimization of MTTR and MSRT and the maximization of MTBF. The following assumptions are made in the identification and application of these techniques:

(1) Data from the MIMMS data bases would support statistical analysis.

(2) Information generated from statistical analysis of MIMMS would be available for use by FMF commands.

(3) Procedures for maintenance operations could incorporate the use of such techniques in the operations of field units.

C. IMPLEMENTATION

1. Process Analysis Technique

The application of process analysis to the maintenance operations of Marine ground force units requires a review of the elements which are an integral part of the process. A review of these components will highlight the complexity and importance of the maintenance effort. An overview of all of these components of the maintenance process will demonstrate how essential it is for the managers in the process to reduce the maintenance process to a descriptive flow diagram for understanding and analysis.

a. Inputs

The maintenance functions of an operating using unit such as an MAU include those necessary to support an infantry battalion and its attached support units. The attached units with maintenance significant items are reconnaissance, artillery, engineers, tanks, amphibious tractors and a logistic support unit. Each of these units has maintenance functions which may affect the equipment readiness of the entire MAU.

The MAU organization consists of six to ten maintenance shops which, most of the time, operate from multiple ships. Table 4 displays the typical day's volume of outstanding equipment repair orders (ERO) in an actual MAU. In addition to the total of 691 outstanding EROs, there was a total of 239 outstanding requisitions for parts needed for these maintenance operations.

The materiel inputs to this multiple shop maintenance process must be considered along with the personnel manning levels. The MAU has approximately 65 maintenance personnel assigned. Some of the personnel may be assigned to jobs only within their Military Occupational Specialty (MOS). However, due to a common knowledge base, some can work in several areas, such as motor transport mechanics on engineer equipment. Skill levels of the individual must also be considered as a part of the personnel inputs.

These input factors lead to the conclusion that the management of the maintenance process of an MAU is a cumbersome and dynamic effort. The managers are subject to an environment of continuous change which requires constant attention. Each manager should use a simple technique to both diagnose problems in day-to-day operations and act as a basis for adjustments to operations.

b. Defining the Process

Process analysis is a simple, obvious method available to every maintenance manager of the organization for defining his process. It is a tool which the managers

Days Old

	Priority	0 -30	31 - 60	61 - 90	over 90	Total
Infantry	1 - 6	8	2	3	20	33
	7 - 15	290	61	10	13	374
Tanks	1 - 6	0	0	0	0	0
	7 - 15	32	0	36	8	76
Artillery	1 - 6	0	6	8	5	19
	7 - 15	70	9	9	17	105
Reconnaissance	1 - 6	0	0	0	0	0
	7 - 15	20	0	0	0	20
Tractors	1 - 6	0	0	0	0	0
	7 - 15	14	12	0	0	26
Engineers	1 - 6	0	0	0	0	0
	7 - 15	19	6	0	0	25
LSU	1 - 6	0	0	8	0	8
	7 - 15	0	4	1	0	5
Total		453	100	75	63	691

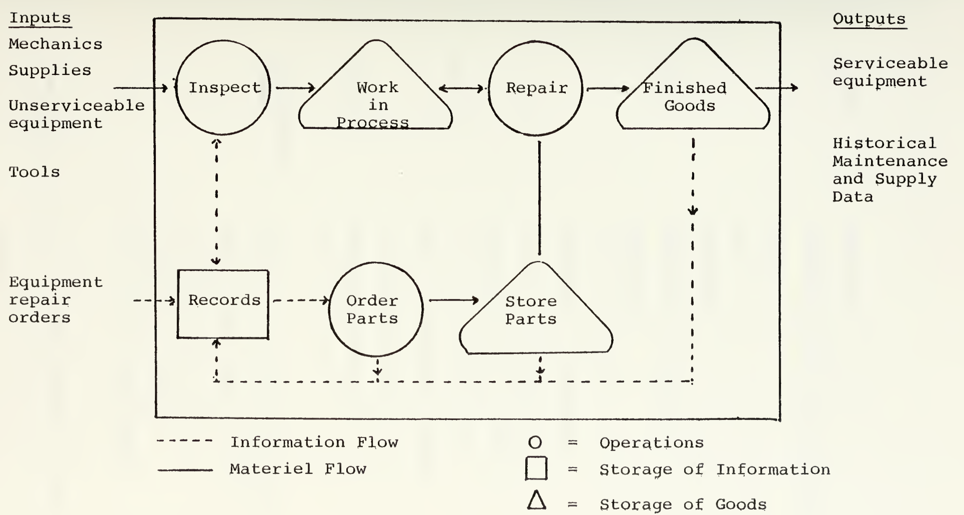
Outstanding Equipment Repair Orders of a Sample MAU on a Typical Day

Table 4

may use in planning, organizing, directing and controlling their operations. Process analysis provides a picture of the flow of materiel and information by which various inputs are converted to a repaired product or output. Inputs such as unserviceable equipment, repair parts, tools, manpower and test equipment are identified by the manager. These are then described as a process of tasks that are performed, flows of materiels and information and storage. These flows are set up in the sequence of occurrence that finally produces the serviceable equipment and historical data output. Figure 9 is an example of a stylized maintenance process.

Each manager could develop a more detailed description of the inputs, tasks, flows, storages and outputs under his cognizance. Table 5 is a checklist of tasks developed by the author which could be considered in generating a maintenance process diagram. The manager, by analyzing capacity and costs of each input, task, flow and storage in the process, can identify problem areas. This analysis is an easy and obvious process available to and within the capability and resources of each manager.

The manager, by looking at what is happening in the process as shown in his flow diagram, is able to identify problem areas and evaluate alternative solution methods. It is the use of this logical discipline that will provide the manager a means to know and understand the interrelationships of the process he is trying to manage to improve the effective use of his resources. The Function,



Process Flow of Maintenance Action

Figure 9

Inputs	-	Deadlined equipment
	-	Preventive maintenance equipment
	-	Tools
	-	Parts
	-	Personnel
Tasks	-	Recovery of equipment
	-	Inspection
	-	Parts orderings
	-	Corrective maintenance
	-	Preventive maintenance
	-	Evacuation of equipment
Storage	-	Parts layette storage
	-	Work in progress storage
	-	Evacuation storage
Outputs	-	Reparied equipment
	-	Historical data
Information flows	-	Reporting of deadlined equipment
	-	Maintenance status reporting
	-	Readiness reporting
	-	Pickup notification
	-	S4 priority assignments

Checklist of Tasks for Maintenance Process Analysis

Table 5

Analysis, Sample and Time (F-A-S-T) system discussed in Ref. 22 is a stey-by-step presentation of a system to improve operating effectiveness. The F-A-S-T system is a simple and complete system for improving operations through measurement and control. The system consists of function analysis, process analysis, sampling standards and time accounting. Ref. 23 describes in explanatory detail the engineering approach to human activity systems. It presents the elements of systems, the physical and non-physical components of human activity systems, and describes the design and evaluation of industrial systems.

2. Planning

Each command must establish operations in a manner which provides for the optimal utilization of its resources. Such planning of operations in the maintenance area should include a prediction of maintenance actions 6 to 12 months in the future. The commander, using these predictions, can define the resources that will be needed to meet these requirements. This aggregate planning is concerned with inventory, personnel, budgeting plans and policies. These plans and policies are interrelated and are the basis for the commander's guidance of operations during the period.

a. Generating Historical Standards

At the heart of the planning process is the ability to forecast requirements. The accuracy of the forecast is a key element in the successful operation of the plan. Prediction, then, is an item of interest to the

commander of a unit and of all senior commanders who build their programs as a summation of subordinate plans. Thus planning is a primary function of the manager and forecasting is an essential element of planning.

There are several factors which must be considered in forecasting maintenance actions; first is the nature of the actions and, second, the operating requirements of the command. Those actions which are fixed in time, such as scheduled preventive maintenance, make up a fixed commitment for resources. Actions such as corrective maintenance are stochastic in nature but means and standard deviations may be predictable, given the density of equipment, historic failure distribution and the planned operations of the unit.

The Marine Corps Integrated Maintenance Management System (MIMMS) contains the following data bases:

(1) Master Equipment File - A record of the cumulative statistical data associated with each individual piece of equipment.

(2) History File - A record of each equipment repair order opened to record maintenance actions performed on an equipment.

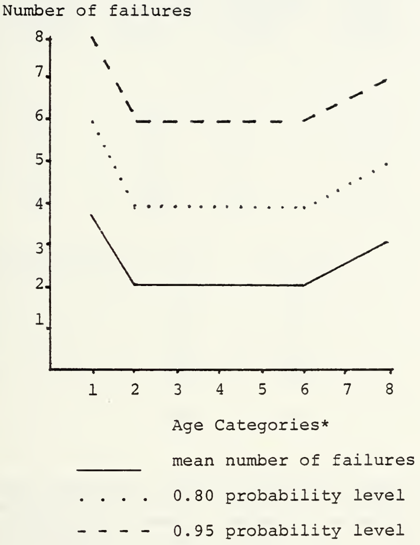
Both files are detailed as to content in Appendix B.

The two data bases contain sufficient data on each piece of serialized equipment for which the manager is responsible to provide him with the factors that should be considered in forecasting his repair requirements. The data bases contain standard measurements such as the mean

number of failures within an age group and the mean equipment operating time between failures. Figure 10 demonstrates a stylized appearance of this data which could be used by a commander in assessing the present performance of equipment and predicting the number of failures during a planning period. Figure 10 is a typical "bathtub" curve for equipment failures wherein the failures are expected to be highest during the phase in of the new equipment and as the equipment nears its life expectancy. Superimposed are parallel curves which are based on different levels of assurance that the number of failures would be less than the given number.

b. Forecasting

The generation of standards and limits of acceptability as depicted in Figure 10 provides the command with the ability to compare individual equipments to the standards and focus attention on the exception equipments. The standards also allow for forecasting maintenance actions based on the number of equipments on hand by age category, adjusted by planned usage, which would have to be developed by the command, and predicted by the range of failure normally experienced by that age category. Table 6 is an example depicting this forecasting. The number of equipments on hand are multiplied by the Poisson predicted failure levels to generate the total predicted failures within each age group. The information could in turn be used in the planning process for inventory, personnel and budget as the forecast of needs.



*Age categories represent equipment operating time range

Failure Levels versus Age Categories

Figure 10

Equipment Age Category	Number of Equipments on Hand	Planning Periods Estimated Equipment Usage *	Number of Age Adjusted Equipments on Hand	Mean Failures per Equipment by Age Category	Poisson Predicted Failure Levels per Equipment	
					0.80	0.95
1	10	500	5	3.7	6	8
2	34	500	31	2.1	4	6
3	10	500	18	2.1	4	6

Total Predicted Failures	at 0.80	at 0.95
Category 1	30	40
Category 2	124	186
Category 3	72	108
Total	226	334

* The figure reflects the impact of planned deployments, training and operating policies such as administrative deadlining that are developed by the command. The data is expressed in equipment operating time such as miles, hours or rounds.

Forecasting Based on Historical Standards Data

Table 6

Standards could be developed for use in the FMF at the Headquarters Marine Corps level. The standards could be developed using both the MIMMS data base available to the Headquarters and any data developed by other services for like equipment. The quality of the standards, considering their generalized use by the FMF, does not have to be exact or precise. A range type prediction standard, such as Figure 10, could provide adequate information for FMF planning.

c. Data Base Quality

The MIMMS Headquarters level data bases, described in Appendix C and held at the Marine Corps Logistic Support Base - Atlantic in Albany, Georgia, are currently not accurate enough to support the development of standards that are generally accurate. Recognizing no malignity nor carelessness on anyone's part, the fact is that while the concept is good the MIMMS data is only in its second year of accumulation and that, initially, the purity of the data was secondary to the successful implementation of the system by the FMF. These conditions have decreased the usefulness of the data base at the present time.

The following deficiencies were encountered while trying to evaluate the ability of the data to support forecasting for the FMF.

Master Equipment File data for the M54 truck ID number 00660D was used as a base. The file contained only 190 serial-numbered records, 10 percent of which had erroneous serial numbers, out of a known total Marine Corps

in-use inventory of over 900. Of the 171 real records only 63 percent had the total equipment operating time (EOT) entries which are essential for life-cycle type forecasts. The validity of the total EOT entries that did exist is highly questionable. Table 7 depicts the distribution of equipment with an EOT by EOT range. Equipment with less than 20 miles and more than 190,000 miles was present on the base.

3. Scheduling

The scheduling of workload to optimize the use of available resources is another fundamental responsibility of the manager. The environmental considerations of the organization impact on the scheduling and dispatch of work in the job shop operations of the FMF maintenance. The direction of this effort is controlled through the assignment of job priorities by the maintenance manager and the command's logistics officer. The priorities reflect the needs of the command for performing its mission and considers the availability of men, money and materiel. An important factor in this consideration is the weight to be given to work backlogged in the maintenance area.

a. Present Measures

The MIMMS procedures, by recording each individual repair action undertaken by the command, are the major source of data on backlog maintenance. The system provides the following type information:

- Number of outstanding repair orders

Mile Range (000)	Number Equipments
0 - 5	43
5 - 10	10
10 - 15	18
15 - 20	8
20 - 25	10
25 - 30	9
30 and up	9

Distribution of Equipment by Equipment Operating
Time Range in Miles

Table 7

- Current job status of the repair orders
- Age spread of the repair orders.

This information is analyzed and from this cumulative overview a "feel" for the impact of the current backlog is developed.

The present system's operation does not provide a bottom-up summation of backlogged, unfinished work. The extent of work still to be completed in each maintenance shop is generated by an overall estimate of the entire backlogged work effort. This process is subject to oversight and misestimation due to the distance of the estimator from the actual work center where the work is being performed. This situation tends to blunt the ability of the command to make rational decisions and policies regarding the scheduling and dispatching of resources.

b. Completion Estimates

The normal processing of repair orders in the maintenance process requires the activity performing the repairs to establish and maintain a record of each repair on MIMMS. A summary of MIMMS transactions is in Appendix C. The process is generally this: a transaction identifying the equipment establishes the repair record. Changes in the status of the job are reported by transaction the day the status changes. Materiel requirements are ordered by recording the data on the established repair record. Finally, when the repairs are completed, the completion data is recorded on the repair record to close it out.

This process provides several opportunities during the life span of an equipment repair order for the maintenance manager to record his latest estimate of the time required to complete each order. Currently MIMMS does not have this data element as an input nor as an output. However, the current configuration of transactions, their process flow and the data base are capable of inclusion of this time estimate without creation of additional input transactions. The maintenance manager could develop and report the estimate of "time to completion" on the change transactions that he currently submits to report changes in job status. Thus, a change to an estimate of time to completion could accompany job status changes such as "from under repair" to "awaiting repair parts" and vice versa.

The sum effect of this additional data would be a recording of the estimates that the manager is currently doing mentally every time a job status change is reported. This data would then be available to provide bottom-up summation of backlogged maintenance work. Time to completion could be associated with other identification data from each repair order. This cross identification could produce current backlog estimates by type equipment, echelon of maintenance and category of repair. Each estimate provides the command a more meaningful measure of the impact of the remaining maintenance time of backlogged items allowing for better use of personnel and materiel in the completion of Equipment Repair Orders that are subject to changing priorities of repair.

4. <u>Training for the Most Likely</u>

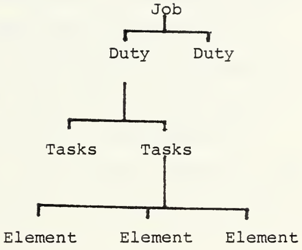
A commander, in developing his training policies in support of aggregate planning, should insure that his personnel resources are oriented toward maximum performance. Planning for the correct number of maintenance personnel in relation to the density of equipments to be supported is one of the needs established in the survey. Closely associated with this is the need to insure that those maintenance personnel who are aboard are proficient in their responsibilities. Commanders, then, are always facing the requirement of improving preparedness through training.

a. Basis for Training

A rational approach to maintenance personnel training is depicted in Figure 11. The overall process is a series of identifications performed best by actual observation of the billet as opposed to a review of the Table of Organization. Each manager could perform this process on a continual basis, incorporating into the analysis the changes that are the result of adjustments to the day-to-day procedures and directions. To be effective the analysis should reflect what is actually being done, assuming what is being done is what is intended.

A current analysis provides a means for each manager to evaluate the elements, tasks and duties of each job. The product of this hierarchical weighing is the identification of intuitively important elements and tasks. One further factor to be considered by the manager is a

1. Identify billets/jobs
2. Identify by actual observation duties that compose the job
3. Identify by observation tasks that compose the duties
4. Identify the elements that compose the tasks



Maintenance Job Analysis

Figure 11

quantification of how his maintenance man-hours were previously expended in support of maintenance.

b. Identification of Training Needs

Maintenance actions which consume a high number of man-hours and which occur with significant frequency are of interest to the manager. Plans must be developed based on maintenance significant events and training should be tailored to insure proficiency and flexibility of personnel to perform these actions. This approach to identifying needs should not, however, preclude the development of proficiencies in low frequency, low man-hour essential jobs where perhaps only a few specialists are needed for these jobs.

The MIMMS History File records the data necessary to evaluate and identify significant maintenance actions. The data is recorded by the echelon of maintenance of the work performed, by the type equipment and the type of defect. Both the man-hours associated with defect correction and the frequency of the defect are extractable from this data base. Table 8 presents a portion of a typical report to demonstrate how the Headquarters level data base could be used to provide the FMF manager a tool for the planning of training.[14] The report identifies by echelon of maintenance the most time consuming and most frequently occurring maintenance actions.

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[14]Systems Division, MARK IV Extract ERO History File, Marine Corps Logistic Support Base - Atlantic, Albany, Georgia, June 1977.

Item:	M54 Truck
Echelon of Maintenance:	Second
Total Number Repair Actions:	214
Total Maintenance Man-hours:	11,594
Time Period Covered:	One year
Number of Equipments:	171

		% of Total Man-hours	Number of Repair Actions
Type Category - Mobility		73.5	154
Type Group Defect	Electrical system	18.2	69
	- control mechanism	6.6	27
	- direct current source	2.0	8
Type Group Defect	Body, frame or hull	11.5	38
	- cracked, broken, bent	5.2	17
	- glass replacement	0.1	3

Man-hours Utilized per Defect

Table 8

With training emphasis placed on the high percentage man-hour and high frequency defects, there would be an increase in the proficiency of personnel in performing the tasks which represent the larger proportion of the command's business. This would increase the flexibility of personnel assignment in a job shop environment by qualifying more personnel to perform the major category type jobs. By cross-stepping the information from the Table 8 type report to the individualized job analysis in Figure 11, tasks and elements can be identified with historically weighted workload values. This can be used by the manager in planning for the effective use of training in his overall planning process.

VII. AN EQUIPMENT READINESS-ORIENTED STOCKAGE POLICY

A. OPERATIONAL BACKGROUND

The survey of logistic system operators, which was described in Chapter IV, identified stockage policy as the fourth area in need of improvement. The performance of the stockage policy affects the equipment readiness of each Fleet Marine Forces (FMF) command which depends upon the inventory for supply support. The Marine Corps has an FMF inventory below the wholesale level worth approximately $270 million. The purpose of this inventory is to provide, within financial constraints, the materiel needed for its units' missions.[15] This inventory, as described on page 22 is managed within the Supported Activities Supply System (SASSY). The SASSY is intended to improve the materiel readiness of the FMF through improved procedures and enhanced policy implementation.[16]

1. Availability

A stockage policy to improve equipment readiness could be identified by evaluating the policy's improvements in supply responsiveness. Availability, response time and backorder volume/age are common measures of responsiveness.

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[15] Office of the Assistant Secretary of Defense Installations and Logistics, Working Group Report: DOD Retail Inventory Management and Stockage Policy (RIMSTOP) Basic Report, Volume I, p. I-2, Department of Defense, 1976.

[16] Marine Corps Order P4400.122A, op. cit., p. I-4.

These relate to equipment readiness in that responsiveness could be measured by the length of time a customer must wait for his requirements to be satisfied.

Those events which adversely affect customer wait time are related directly to equipment readiness through the definition of equipment availability. Availability is that percent of time equipment is operationally ready. Availability is the mean time between failure (MTBF) divided by the sum of MTBF, mean time to repair (MTTR) and mean supply response time (MSRT).[17] The formula for availability is:

$$\text{Availability} = \frac{\text{MTBF}}{\text{MTBF} + \text{MTTR} + \text{MSRT}}$$

Thus a policy which reduces the MSRT will improve equipment readiness.

2. Readiness and Supply Support

An analysis of a piece of common operating equipment in the FMF helps to identify the relationship between equipment readiness and supply support. The supply support provided to FMF equipment users is directly impacted on by stockage policy. The M54 five-ton truck, common to artillery, engineer and tank battalions, illustrates this relationship in FMF operations.

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[17] Office of Assistant Secretary of Defense, Installations and Logistics, Working Group Report: RIMSTOP Volume III, p. III-3, Department of Defense, 1976.

Each M54 averaged 64 days out of operational service during the past year. The distribution of the days to repair an M54 at the second echelon of maintenance is described in Table 9.[18] The amounts of time the equipment is not available for use are significantly contributed to by the supply support responsiveness of the current stockage policy. An analysis of repair parts used at each echelon of maintenance was performed. This analysis developed a picture of the quality of supply support for all items and that support provided on high demand items. Items were considered high demand if they had 15 or more demands per year recorded on the MIMMS History File. The supply response times for these parts was 18.7 days for all items and 19.1 days for items with more than 14 demands per year. Table 10 shows the distribution of the percent of receipts by days to receipt for items at the second echelon of maintenance that had over 14 demands per year.[19] The overall impact is that supply support response time amounts to 29 percent of the time that the equipment is not available for operational use. This percentage of time was computed as the Average Mean Days to Receipt divided by the Average Mean Days Out of Service for second echelon of maintenance.

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[18] Systems Division Code 736, MARK IV Extracts of MIMMS History File, Marine Corps Logistic Support Base - Atlantic, Albany, Georgia, August and September, 1977.

[19] Loc. cit.

2nd Echelon of Mainenance

Distribution of the Percent of Items Repaired

by Days to Repair

Percent back in service	25	48	59	70	79	90	95
Days	10	20	30	60	90	120	180

Distribution of Days Out of Service

for the M54 Truck during July 1976 to July 1977

Table 9

2nd Echelon of Maintenance

Distribution of the Percent of Receipts of Items with Greater than 14 Demands by Days to Receipt

Percent of receipts	27	53	82	90	95	100
Days	10	15	20	25	30	62

Supply Response Time for M54 Trucks

Table 10

Inventory records were analyzed to identify the quality of supply support available today for the M54 truck. A sample of the 57 most frequently demanded M54 repair parts on the MIMMS History File were used to query the current general account inventory records of the I MAF SASSY Mangement Unit (SMU) at Camp Pendleton, California. This survey identified that 75 percent of these high demand items had previously been recorded by the SMU as in the top 30 percent of the general'account's demand and dollar value business. However, only 83 percent of these sample items had assets available for immediate issue. This fill rate, although better than the average as depicted in Figure 5, indicates that even the high movement and dollar value items are not available on a high quality support basis.

The purpose of this chapter is to examine the desirability and feasibility of modifying today's stockage policy. The use of a simulation model to aid in the development and implementation of changes in today's stockage policy is demonstrated in this chapter. Simulations are used to illustrate the effects of change on different pieces of the policy and to compare the performance of an alternate policy with today's policy.

B. PROBLEM

1. Statement of the Problem

The problem statement is: Is there a better stockage policy than that of today's straight days of supply? The

typical criteria will be the maximization of availability and the minimization of wait time subject to limited funds.

2. Limitations

The simulations were limited in number and diversity of parameters due to both time available and limited supporting computer resources. Additionally, a more complete and meaningful set of simulations would require the participation of top-level management decisions in variable areas such as funding, phasing of implementation with operational commitments, facilities and equipment planning. The simulations, however, are a demonstration of the capability of an alternate policy to improve equipment readiness through better supply support performance.

3. Methodology

The simulations of stockage policies used the Department of Defense Retail Inventory Management and Stockage Policy (RIMSTOP) simulation model. In the model demand is allowed to be random and stockouts can occur. The sensitivity of the results are analyzed in relation to changes in cost to order and hold, methods for computing safety stock levels and various add and retain stockage criteria.

C. IMPLEMENTATION

1. Simulation Background

The rational development of a stockage policy requires the evaluation of the potential results of implementing the policy. The use of simulations provides the policymaker with

a means for measuring the future impact of a policy. Simulation is the processing of a model of the policy in a manner that imitates the actual performance of the supply support system. The analysis of multiple iterations of the stockage policy evaluating different policy parameters provides the policymaker with alternative choices. The alternatives and their impacts on operations allow the policymaker to exercise a rational choice.

The RIMSTOP simulation model was developed for a retail inventory that could exist between the wholesale level and the SASSY inventory which is both the MAF's mobile consumer-funded and controlled inventory. The principles and techniques of inventory management incorporated in the model are currently accepted state of the art and, as such, applicable to the SASSY general account inventories, although the definition of these inventories may be other than purely retail.

The simulation programs of the model use as inputs three files representing Master Item Records, Requisition Transaction Histories and a Demand History File.[20] These inputs were taken from actual files and historical transaction data of the II MAF at Camp Lejeune, North Carolina. The model simulated inventory operations over a five year period, thus allowing the effects of the policy parameters

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[20] Defense Logistics Agency, RIMSTOP Consumable and Reparable Supply Point Simulation Models, pp. 3-5, Operations Research and Economic Analysis Office, 1977.

to be studied as a fully implemented system. The programs produced output data in the format of reports for descriptions of parameters, performance, investment, workload and costs. The simulations reported below were run on the Defense Logistic Agency's IBM S/370-155 computer.

2. Objective

The purpose is to demonstrate the use of the simulation model in the process of establishing a stockage policy. In attaining this end a goal of maximizing readiness related factors, such as wait time and availability, was established subject to the requirements of limited investment funds and the desirability of minimizing operating and holding costs. This goal parallels the current Marine Corps inventory operating goal of a 75 percent fill rate.

3. Methodology

A series of simulations were completed to compare the operation of today's stockage policy with alternate policies that reflect basic changes. Simulation results of each policy were analyzed to produce graphs. In each simulation only changes in one area were made in unmasking the impact of each policy change.

The graphs of results identify what percent increase or decrease in costs could be effected at the same performance level by use of the alternative policies. Alternately, the graphs identify what percent improvement in performance could be attained while costs are kept equal.

4. Performance Terms

The objective of a stockage policy is to provide parts to keep systems and equipment in an operational status. One measure of how well parts are provided is indicated by the measure of how well customer requisitions are filled. Although fill measurement, due to the variableness of a part's importance to equipment repair, only indicates a direction in the quality of support for equipment readiness, it is a reasonable surrogate for the measurement of the performance objectives. This approach to measurement of stockage policy follows the one described in Ref. 28 as presently used by the Marine Corps.

a. Fill Components

The following measures are fill-type measures and consider availability, time and stockage:

(1) Line Availability - Requisitions for all items over a specified time period are counted in this measure. A requisition is considered filled only when it is totally satisfied from stock on hand. Partial fills are not credited to line availability. The formula is:

$$\text{Line Availability} = \frac{\text{All requisition completely satisfied from onhand stock per year}}{\text{Total requisitions received per year}}$$

(2) Unit Availability - The quantities of all requisitions are counted in this measure. This measure does count partial fills. For example, when a quantity of 4 out of a requested 5 are on hand, unit availability equals 0.80.

By contrast, the same conditions would produce a line availability of zero. The formula is:

$$\text{Unit Availability} = \frac{\text{Quantity satisfied from stock on hand per year}}{\text{Total quantity requisitioned per year}}$$

Line and unit availability are measured as gross when both stocked and non-stocked items are included in the measure. Net line or net unit availability is a measure that includes only stocked items.

The measurements of availability by line (requisition) or unit (quantity) have benefits and deficiencies. The immediate end use of requisitioned parts by a customer would be better measured for system responsiveness by unit availability. Responsiveness to requisitions for bin or shelf stockage may be better reflected in line availability measurements.

Multiple quantity transactions which were subject to partial issues made up 50 percent of the II MAF documents used in the simulations. 30 percent of the requisitions were for a quantity of three or more.

(3) Line Wait - Line wait equals the average customer wait by requisition. All requisitions for stocked and non-stocked items are counted. Customer wait time ends when the total quantity requested is satisfied. Partially filled requisitions are not counted as satisfied until the full amount requisitioned is received by the customer. The wait time for requisitions immediately satisfied by stock on hand is zero.

(4) Unit Wait - Unit wait equals the average wait for one unit of an item. All requisitions are counted. Each increment of a partially filled requisition is counted. The count is the sum of the product of quantity filled times the time required to complete the fill. For example, an immediately filled requisition for quantity 5 and a requisition originally for quantity 9, filled in part the first day and in toto the thirtieth day, would be computed as follows:

First requisition	5 units x 0 days	=	0 unit days
Second requisition	3 units x 0 days	=	0 unit days
	6 units x 30 days	=	180 unit days
	Total	=	180 unit days

The unit wait $= \frac{180}{14} = 12.9$ days.

(5) Accommodation - The fraction of demands that are for items which are stocked is a measure of accommodation. The measure is of the frequency that the demand is accommodated by the stockage list. It is measured in either number of requisitions (lines) or quantity (units). The formula is:

$$\text{Demand Accommodation} = \frac{\text{Number of demands (lines or units) for stocked items}}{\text{Total demands (lines or units)}}$$

b. Cost Components

(1) Operating and Holding Costs - These variable costs have direct influence on stockage policy. Operating

costs include ordering costs, item addition and deletion costs, and item maintenance costs. Add and delete costs are the administrative costs of increasing or decreasing by one the number of different items in stock. Included are initial replenishment, records construction and complete disposal costs. Item maintenance costs are the sum of administrative costs incurred annually because the item is on the stockage list. It reflects, for instance, costs of those actions that require review of all item records or actions that require going through the warehouses from wall to wall. Holding costs are the monetary penalty for having an inventory such as the charge for funds invested, loss due to obsolescence and other inventory and stockage costs. The values associated with each cost were selected from previous RIMSTOP data in Ref. 27 and are listed below.

Requisition Costs	
Replenishment	$5.00
Backorders	0.50
Turbulence Costs	
Add costs	0.50
Delete costs	5.00
Costs to Maintain Item per Year	
Stocked	25.00
Non-stocked	25.00
Holding Costs Rate (%) per Year	
	0.20

(2) Investment Costs - The investment cost is the dollar value associated with the number of units of each item stocked. The number of units was computed as the sum for the fifth year simulation of average on-hand and the average dues-in minus the average dues-out.

5. Comparisons

The basic points of a stockage policy are what items to stock and how many of the items should be stocked. These considerations are the range and depth of the stockage policy. Range and depth may be either fixed or variable in nature. A fixed policy is one where the same value is assigned for all items in the inventory. Today's Marine Corps policy is a fixed policy where the criteria for adding to and deleting an item from the stockage list and the levels of stock in safety level and operating level are the same for every item. A variable policy has values that differ between items or groups of items based upon an item or group characteristic such as cost or expected demand rate.

a. Range Results

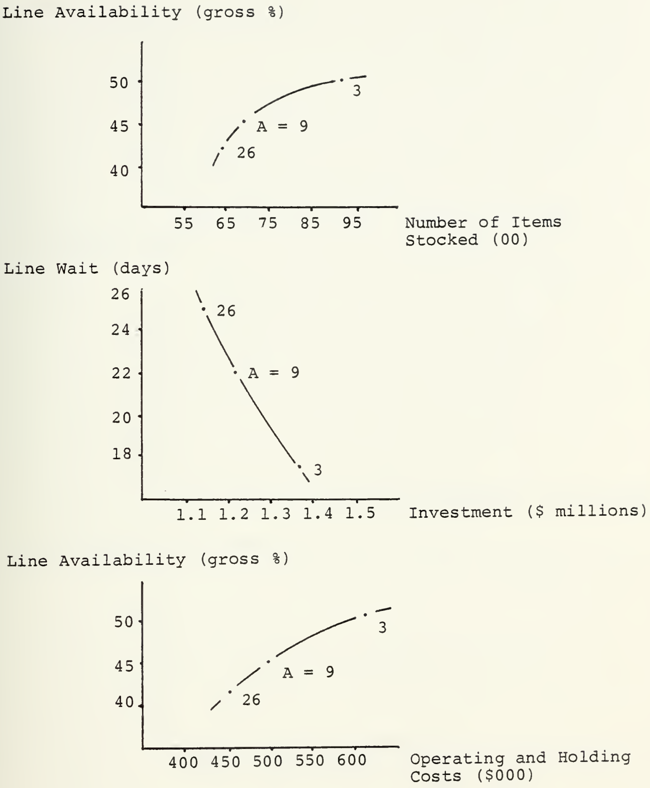
A stockage policy that would always provide immediate supply support when requested is not practical since it would require the stockage of all items. The Marine Corps stocks in an effort to best support a customer requirement within limitations or constraints of budget dollar and warehousing space. The current method used by the Corps to define its range is an add and retain criteria expressed in terms of demand frequency. To add an item to

the list of currently stocked items requires four demands during a twelve-month period. Any stocked item that does not currently have at least one demand in a twelve-month period is removed from stockage.

Simulations of what could happen when changes are made in add and retain criteria are shown in Figures 12 and 13. During these simulations the other stockage parameters were held constant so that only the effects of changes in the range criteria could be observed. The add criteria becomes more restrictive as the number of demands required to stock an item increased. The data shows, as expected, that as it became harder to qualify an item for stockage, the number of items stocked was reduced. Performance in availability and line wait time decreased. Operating and holding costs decreased with the lower number of stocked items.

The effects of changing the retain criteria are also shown in Figures 12 and 13. The retain criteria becomes more restrictive as the number of demands to retain an item on the stock list becomes higher. The results show that as the retain criteria became more restrictive, the number of stocked items, costs and performance decreased.

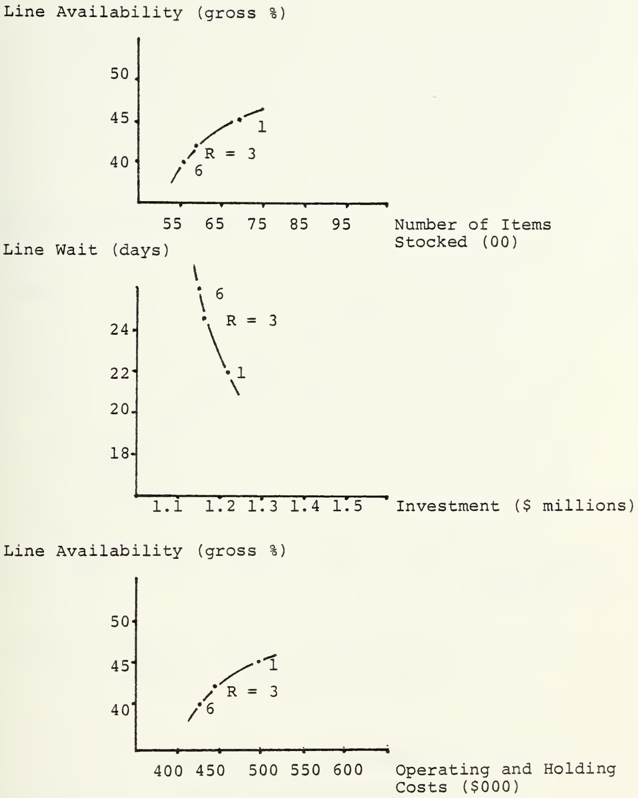
When the add and retain data discussed above in Figures 12 and 13 are analyzed, they suggest that changes in the add criteria provide a better performance per dollar cost than do changes in the retain criteria. Figure 14 shows this relationship.



A = Number of annual demands to add an item to stockage list.

Variable Add Criteria Comparison when
Retain Criteria is a Constant of One

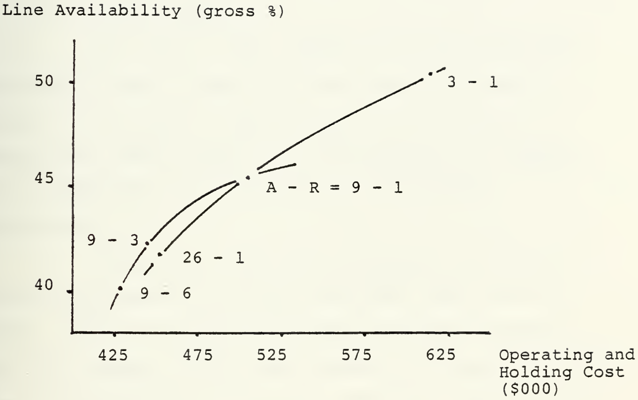
Figure 12



R = Number of annual demands to retain an item on stockage list.

Variable Retain Criteria Comparisons when
Add Criteria is a Constant of Nine

Figure 13



A - R = Number of annual demands to add (A) and retain (R) items on the stockage list

Comparison of Performance and Costs for Add and Retain Criteria

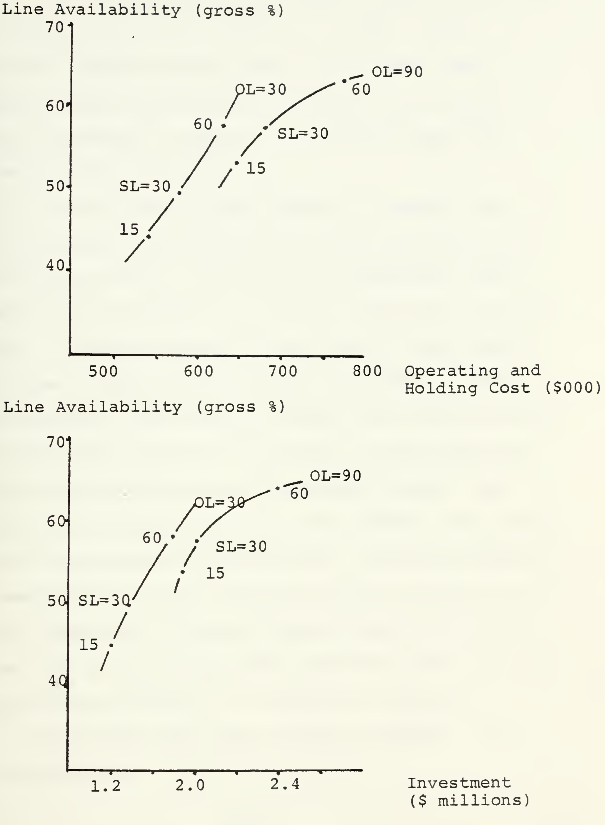
Figure 14

The slope of the lines in Figure 14 determines the performance relationship where the higher sloped line provides the better performance for the cost. At the point 9-1 line availability will be much more improved per dollar of additional cost by reducing the add criteria than by reducing the retain criteria.

b. Depth Results

The Marine Corps' present inventory levels are expressed in days of supply and are based upon demand history. The number of days of supply are determined by Headquarters Marine Corps decisions considering a combination of operations, fund availability and desired performance.

Simulations were run to evaluate the impact of varying the operating level and the safety level days of supply. During the simulations other stockage parameters were held constant so that only effects of changes in safety level or operating level could be observed. Figure 15 shows the performances of operating levels with 30 and 90 days of supply. The effect of varying the safety level days of supply within these two operating levels is demonstrated. Holding the operating levels constant and varying the safety level resulted in increased operating and holding costs, investment costs and improved performance. When the safety level was held constant, variation of the operating level also increased investment and improved performance.



Comparisons of Operating and
Safety Level Changes

Figure 15

It is observable from Figure 15 that, given the choice between increasing operating or safety levels, it is better to increase safety level. The safety level increases provide more improved performance per dollar invested or expended in operating and holding than did an operating level increase.

Simulations provide a means to examine the impact of changing the Marine Corps fixed operating level policy by substituting a variable policy operating level. Considering goals of higher performance and lower costs of operations, a simple economic order quantity (EOQ) model could be used to replace the present fixed days of supply operating levels. Two common inventory costs are the costs to order and costs to hold an inventory. These costs are inversely related and usually at different rates. The ordering of a large quantity of an item reduces the ordering costs but incurs greater holding costs. The EOQ identifies the trade-off point where the order costs and holding costs are equal quantities. The EOQ formula used in the simulations was the standard Wilson EOQ described in Ref. 25 with the operating level equal to a minimum of one month of supply, but not more than twelve months of supply. The EOQ is computed as:

$$EOQ = K \cdot \sqrt{\frac{D}{C}}$$

where

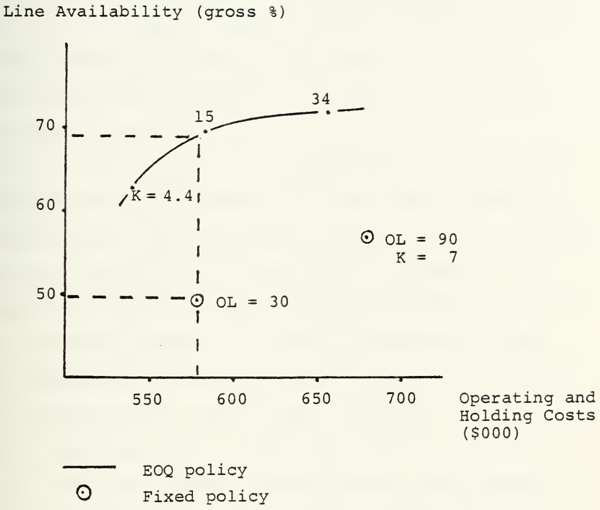
$$K = \sqrt{\frac{2A}{I}}$$

D = Demand per year in units
A = Ordering cost
I = Holding cost rate
C = Item unit price

During the simulations other stockage parameters were held constant so that only effects of changes in ordering and holding costs could be observed.

Since lower priced items have higher EOQs than higher priced items with the same demand rate, then in comparing fixed versus EOQ policies, EOQ has two results. First, for the same costs expended on an inventory having the same stockage list, the EOQ policy will have more units stocked per dollar cost than the fixed policy. Second, the higher stockage quantity of the EOQ should provide for a better supply performance. Additionally, as the K factor is increased, the EOQ numerator becomes larger, increasing the resultant quantity and therefore improving performance at the cost of increased holding costs.

Figure 16 provides a comparison of the costs and performance of fixed operating levels versus the variable EOQ operating levels. It is obvious that the variable operating levels are more efficient than the fixed ones. The variable policy provides more performance at both the same and at lower costs as the fixed policy.



Comparison of Fixed versus EOQ Operating Levels

Figure 16

c. Alternate Model Results

The above comparisons looked at the effects of changing one stockage policy parameter within the model of the current Marine Corps inventory. The contribution that each change in policy could make towards attaining a performance goal can be assessed through simulation. The desirable changes can also be combined to form a more elaborate alternative policy which could be compared to the current stockage policy.

The following is a comparison of an elaborate alternative model and the Marine Corps present fixed days of supply model. The alternative model is one which is well within the capabilities of the Corps to implement. The components of the alternative policy are common to Navy and Army inventory programs. The SASSY environment of the FMF, combined with the system development function at the Marine Corps Logistic Support Base - Atlantic, are two factors that allow the implementation of the alternative policy. These two factors remove from both the implementation and operation of the alternative policy the burden of handling and controlling the added complexity of the alternative within the limited personnel resources in the FMF. Additionally, the two factors allow the FMF logistic structure to improve its operational effectiveness to the degree that the Marine Corps logistic readiness goals could be attained.

The parameters used for the simulation of the present policy of the Marine Corps are as follows:

(1) Add an item to stock when it has received four demands in a year.

(2) Retain an item as stocked when it has received at least one demand.

(3) Compute the reorder points and requisition objectives monthly.

(4) Compute the operating level as 30 days of supply.

(5) Compute the order ship time level as equal to the average days to receipt.

(6) Compute the safety level as 15, 30 and 60 days of supply.

(7) Maintain current management fixed stockage levels during simulation.

(8) Compute the excess retention level for all items equal to requisition objective plus three years of stock.

The emphasis of the alternative policy was the use of computations to determine which items to stock and the amount to be stocked. The simulation of the alternative policy used the following parameters:

(1) Compute the order ship time level as equal to the average days to receipt.

(2) The determination of items to be added to and retained as stocked was based on the Navy's Variable Threshold Rule. A value is computed which is the imputed cost of adding and deleting an item on the stockage list. The value is computed as the ratio of the probability of one or more demands during lead time and the unit price of

the item. This ratio represents the marginal decrease in the risk of a stockout per dollar of item added. The formula for the value is:

$$V_i = \frac{(1 - e^{-D_i L_i})}{C_i}$$

where

i = the ith item in the inventory

D_i = mean demand rate of the ith item in units per month

L_i = order ship time of the ith item in months

C_i = unit price of the ith item.[23]

The simulation used .010 as the value threshold that must be exceeded for an item to be stocked. The retention threshold was .001. The use of the unit price as the denominator reduces the chances of stocking a higher priced item. The use of the probability of one or more demands as the numerator reduces the stockage of low demand items compared to high demand items.

(3) Compute the reorder point and requisition objectives monthly.

(4) Compute operating level as an economic order quantity as previously described.

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[23]Defense Logistics Agency, op. cit., pp. B-167, 168 and B-210, 211.

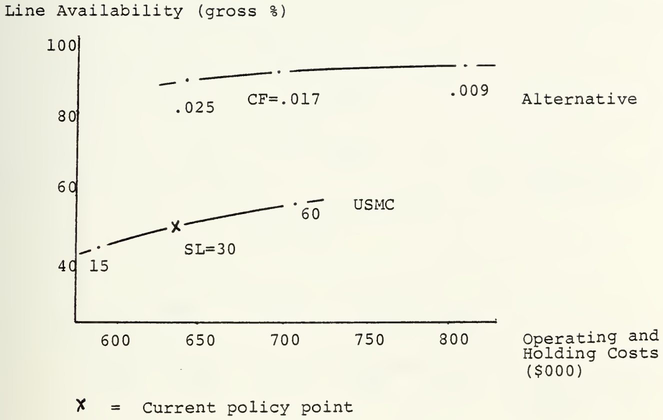
(5) Compute the safety level based on the Navy's Variable Operating and Safety Level (VOSL) program. This program considers the risk of a stockout during order ship time and management's consideration of cost constraint in the form of a cost factor. The cost factors used were .009, .017 and .025. The computation of the safety level is described in Appendix D.

(6) Items are stocked solely upon the above parameters.

(7) Compute excess retention level for all items equal to the requisition objective plus three years of stock.

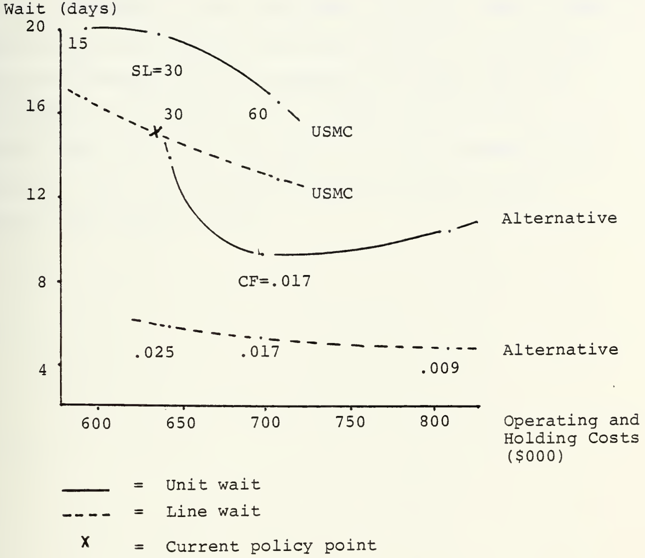
The responsiveness of the variable policy to meeting the Marine Corps current availability goal is shown in Figure 17. The variable policy produced a line availability percentage that was approximately 50 percent better than the current policy. It also exceeded the availability goal. The current policy was not able to attain more than 80 percent of the availability goal.

Figure 18 shows that the alternate policy has a wait time performance that, on a unit wait basis, is approximately 170 percent more effective than the current policy. The line wait responsiveness of the alternate policy is approximately 300 percent better than the current policy. These two improved wait time measurements indicate a marked reduction in the mean supply response time (MSRT) use in the computation of equipment availability. The reduction



Comparison of Line Availability between
Marine Corps and Alternative Policies

Figure 17



Comparison of Wait Times between
Marine Corps and Alternative Policies

Figure 18

in MSRT produces an increase in the availability of equipment for the FMF commander.

Table 11 contains data comparing the performance of the alternative policy with today's policy. The alternative policy has a safety level cost factor of .025 and was selected because it had approximately the same total sum of operating and holding costs. Today's policy has a safety level of 30 days of supply. Each performance measure indicates that the alternative policies produce better support than today's policy.

Measurements	Today	Alternative CF = .025	% Change
Line Availability, gross %	52.3	88.0	+ 68
Line Availability, net %	67.0	95.8	+ 43
Unit Availability, gross %	34.8	58.1	+ 67
Unit Availability, net %	36.3	54.1	+ 49
Line Accommodation %	71.5	72.4	+ 1
Unit Accommodation %	82.4	86.2	+ 5
Percent of Demands Backordered for Stocked Items, 5 yr. average	19.8	4.9	- 75
Wait Time, Unit 5 yr. average	20.0	14.0	- 40
Wait Time, Line 5 yr. average	15.2	5.8	- 62
Average Net Investment ($000)	1502	1477	- 2
Range of Stocked Items	8203	14,007	+ 71
Operating Cost ($000)	337	385	+ 14
Holding Cost ($000)	290	258	- 11

Today's and Alternative Stockage Policy Data

Table 11

VIII. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

A. SUMMARY

The continuing evolution of the Marine Corps logistic support structures provides opportunities for improvements in equipment readiness of the Fleet Marine Forces. Rational management objectives in equipment readiness must also be continually updated to match the Marine Corps mission needs with what is both desirable and feasible within the logistic arena. Objectives must be found that are warmly supported by the Marines in the field and at the Headquarters level. Through such common objectives all Marine Corps levels can make their contributions to equipment readiness.

A survey was conducted and identified the three significant areas of command interest, personnel, and procedures as needing improvement. These areas were determined by the logistic system operators as those which would enhance equipment readiness in the Fleet Marine Forces. These same areas were demonstrated on page 44 to be those generally desired by officers assigned to command billets receiving significant logistic support.

Command interest enhancement was discussed from the viewpoint of the need of the commanders to have knowledge of both principles to improve their effectiveness and a procedural model. Management by objectives was presented as a business-oriented management model that could be used to

put the commander's interests and goals into action throughout his organization.

Managerial techniques were suggested, but are not described in detail, for use in improving the effective use of personnel. The techniques were selected based on their simplicity for use in the field and because they are easily supported by the present day supply and maintenance systems of the Fleet Marine Forces.

Finally, equipment readiness was examined from the procedural side by several analyses of the impact of stockage policies upon performance. The policy was broken down into segments which could be changed both independently of each other and implemented on an incremental basis. The use of performance objectives, along with a use of multiple iterations of a simulation model, was demonstrated as a technique applicable to the search for a more responsive and more readiness-oriented stockage policy. The primary goal of the policy is to maximize fill-rate subject to the budget and perhaps storage space constraints. The economic worth of implementing a variable order quantity, and variable operating level model was examined. In addition the need to identify and use a performance objective instead of identifying shortage costs was illustrated.

B. CONCLUSIONS

1. Goals

Goals can be established to improve equipment readiness which are desirable to both the system operators in the

field and at the Headquarters level. Such common objectives are much easier to attain because both management levels can see the contributions that each is making for each other's benefit. The use of a delphi type survey provides a means for goal identification. These composite goals are not a perfect resolution of all management desires, but rather they present a quantifiable description of needs. Goals tend to lose some of the grayness common to managerial judgments after they have been massaged in the multiple iterations of a delphi survey.

The use of the delphi technique does tend to converge opinions of participants on the dominant goal. Further consensus between participant seniority classes on each individual goal can be arrived at by the delphi technique.

Factors of participant objectivity, the subjectivity of opinions, and the structuring of the approach, statements and responses make the overall accuracy of the goal rankings more directional in nature rather than precise measurements.

2. Command Interest

Management by Objectives (MBO) is a model that could be used by a commander to improve his influence over the business operation of his unit. The commander could use MBO as a vehicle to move his unit in the direction which he establishes. The commander's goals for the unit are interpreted down through the organization by each subordinate manager. The managers select objectives within their areas that support the overall goals of the unit, thus causing the unit's operations to follow the commander's directions.

The MBO approach complements and builds on the principles of effectiveness. MBO is a systematic approach that provides the structure wihtin which the manager can both perform his functions and operate effectively. The system includes consideration for planning organization goals, use of coordination and controls, improved utilization and development of personnel and a means for evaluating the effectiveness of managerial efforts.

Management by objectives is the business management model that could serve as a vehicle for the commander in putting his command interest into action. It establishes agreement between the commander and his subordinates on what is expected. The MBO model reduces the number of unexpected events and builds committed and motivated subordinates by having subordinates establish objectives and be responsible for their attainment. The focus of the system is on opportunities and results, while at the same time providing a means for appraisal based on results.

3. Personnel Effectiveness

The effective use of personnel can be enhanced by using simple techniques combined with information from present day logistic systems. Once the need to improve the use of personnel is an agreed upon goal, then by selecting managerial techniques which are available and imaginatively combining them with information from today's logistic system, improved effectiveness of available personnel can be attained.

Improvements in personnel effectiveness must recognize the limits imposed by the need for simplicity in techniques and the use of information from present day logistic systems.

a. Process Analysis

Process analysis is a technique to help the manager identify problem areas in the overall operation of his organization. The information needed to perform this analysis is currently known to or available to the manager. The maintenance process of a Marine Amphibious Unit (MAU) was used to illustrate both the need for the use of the process analysis technique and show how it may be applied.

Improvements in the operation of the maintenance process result from the manager understanding the interrelationships of inputs, outputs, tasks, flows and storages within maintenance operations processes. A clear and logical display of these relationships allow the manager to make changes to the process which have the effect of improving equipment readiness by reducing bottlenecks and inefficiencies in both materiel and information flows. The maintenance process of an MAU is a complex and constantly changing array of requirements and constraints. The manager's ability to understnad and control this operation is improved by the use of process analysis in the maintenance program.

b. Planning

Managers can plan and organize their operations and use personnel better by using information from the supply and maintenance systems as a basis for predicting

future workloads. The current maintenance system in the Fleet Marine Forces is designed to collect data on equipment failures. The systematic extraction and formulation of failure estimates by type of equipment based on total Marine Corps experience could be used in planning phases of unit operations. Failure data, combined with planned equipment usage and equipment densities, could quantify for the unit commander and staff the type of workload that may be experienced during the planning period.

The degrees of sophistication that historical failure data may be put to ranges from computer-oriented applications to simple lists used for manual estimating at the lowest maintenance echelon. Each approach could have the benefit of quantified experience as opposed to today's use of the limited operational experience of the managers. Combined with the quantified failure experience could be the use of commander planning guidance in the form of assurance levels of failure occurrences. Using these combined inputs, the managers can estimate personnel requirements, repair part demand changes and dollar requirements.

The quality of the Marine Corps-wide data base is fundamental to the development of failure estimates. Current data base quality will have to be enhanced in order to establish generally reasonable estimates. A mechanism for the cleanup of the data base could be established in the field so that upgrading occurred as a normal part of day-to-day operations.

c. Scheduling

Planning for the effective use of personnel requires an understanding of the scope of the workload faced by the manager. This measurement of workload is done today and, in most cases, this information is available only to the first line manager. The present maintenance system provides measures of volume and current status of work in the maintenance process. The amount of effort in terms of man-hours to complete the work backlog is the element of information not captured as an input to the maintenance system.

The first line manager in the maintenance process does, at a minimum, develop mental estimates of man-hours to completion of each work order in his area of responsibility. This information is not in a form that allows the manager to find the balance between repair priorities, personnel availability, work space and overall production. This mental record of man-hours to completion of work orders is not available in a useful form to senior management levels for use in assessing the current status of a unit's (or the major command's) equipment readiness posture. Scheduling and dispatching activities do not operate on an effective basis because of lack of this information.

The present system's informational flow, transactions and processing can be altered to incorporate "time to completion" estimates. These completion estimates could be incorporated with the current job status reporting

requirements, so that the current mental efforts of the first line manager are reported and recorded for use at both his and senior levels. The addition of this information and its summary forms could improve the manager's ability to more effectively use his personnel.

d. Training

Effective use of personnel requires that each employee be capable of performing those tasks which the manager identifies as contributing most to the optimal performance of the unit. Managers can combine two efforts which could contribute to making employees more capable of performing their jobs. These efforts direct the emphasis of training to training employees for the more critical and most likely tasks.

The first technique is for the manager to perform a task analysis of each job that he supervises. This type of analysis identifies from the bottom up the elements, tasks and duties that an employee must accomplish to be effective. This detailing of each employee's job allows the manager to define areas that his experience has labeled as important for the effective use of the employee.

The second technique is to extract, by equipment type and echelon of maintenance, historical man-hour expenditures for the various maintenance tasks. The extracted information is provided to each manager in a form that allows him to identify areas of his operation which consume the largest percentage of his personnel resources. This historical

data is currently available from the maintenance system in the Fleet Marine Forces and could be consolidated by equipment type to provide a Marine Corps-wide basis for man-hour utilization analysis.

The maintenance manager can combine the results of his job analysis and the historical man-hour utilization analysis to form a rational, low-cost approach for tailoring his training. By tailoring the training of his personnel to better support the maintenance needs of his unit, as identified by the combined use of job and historical manpower analysis, the manager increases the effective use of his personnel.

4. Stockage Policy

The impact of the Marine Corps stockage policy on equipment readiness is direct and related to the response time a customer may expect in obtaining required repair parts. Limited inventories are positioned at the organic using unit levels within each MAF to enable these units to be highly mobile with minimal internal supply support capabilities. The inventories funded and controlled by the Marine Amphibious Forces general accounts are intended to support the unique requirements inherent in maintaining these mobile tactical forces in an operational environment where the required parts are critical to equipment readiness.

The RIMSTOP inventory model, while aimed at retail level inventories that are not exactly equal to the general account inventories of the Fleet Marine Forces, has component

principles which are well applicable to improving the general account's support of equipment readiness. Because these principles so directly affect today's essential readiness mission of the Marine Corps, their appropriate incorporation and application to the Corps' mobile inventories is fundamental to the adequate management of equipment readiness responsibilities.

The application of a variable safety level would enhance the availability of stocked items by reducing the current, approximately 30 percent out-of-stock rate. The stock outages occur when demands during order ship time exceed on-hand assets. It is desirable for the stockage policy to recognize a need to stock a safety level in anticipation of the probability of demand during order ship time. The extraordinary investment costs associated with the assurance of a very high safety level is limited by a real-world policy which recognizes fund constraints and defines a feasible availability rate.

The application of an economic order quantity with maximum and minimum level constraints has been demonstrated to be economically desirable when compared with the current policies. The use of an EOQ as an operating level tended to improve the responsiveness of the stockage policy in availability, wait time and backorders. The manager must incur the expenditures for studies necessary to identify the cost to order and hold associated with the operations of the general accounts in order to use an economic order quantity.

Add and retain criteria may be used to control the availability and wait time of the stockage policy. Adjustments to the add and retain criteria are reflected in the range of items stocked and the investment in inventory. The higher the add criteria, the lower the range of items stocked. The same effect on range of stockage results from reduction of the difference between the add and retain criteria.

The combined application of the use of an economic order quantity, a demand-related variable safety level along with a variable add and retain criteria can produce a stockage policy which is more responsive, although it is considerably more complicated than today's policy. Along with this policy, the use of an iterative model can aid in identifying the policy which best satisfies management's goals and constraints.

The independent nature of each of the principle components of a stockage policy adds flexibility in the implementation of a stockage policy. An all-at-once change of policy is not required nor is it necessarily desirable. A policy change such as a variable safety level could be implemented without the use of an EOQ operating level. The flexibility of the independence of policy segments extends to the application of segments to items in the inventory. Again, the variable safety level could be implemented initially for only those limited number of items that make up the majority of demands for equipment

readiness-related repair parts. The manager could then evaluate the actual economic and operational performance of the model-tested policy on an incremental basis.

C. RECOMMENDATION

Further study should be made into ways to improve the equipment readiness of the Fleet Marine Forces units, allowing the application of more time and resources than were available during this thesis.

The efforts to improve equipment readiness should be designed to accomplish in a planned manner those goals which reflect the composite position of both the Headquarters and field operators of the logistic system.

Management by objectives should be used as a model for converting command interest into action. MBO should be taught at the various service schools as an effectiveness-enhancing approach that allows a commander to transform his command interest in logistic support functions into objectives supporting his overall goals for the unit. The commander should involve his subordinates in the attainment of objectives which sum up to the overall goals of the command.

Techniques of production management such as process analysis should be identified and applied by incorporating their use in the training and day-by-day operations of the managers in the Fleet Marine Forces.

Inventory cost factors and an inventory model applicable to current organizations should be developed for use in the generation of an up-to-date stockage policy. Further study should be done to identify the type of inventory model to use in order to best meet the goals and constraints of current operations.

Sets of parameter goals should be established, recognizing current needs for availability, wait time, number of backorders and net investment, so that ordering and stocking policies can be identified through simulations that will satisfy these goals.

Following such an analysis a phased plan for implementation of any new stockage policy more supportive of equipment readiness should be developed and put into effect. The plan should improve performance by starting with a combination of investment and operating and holding costs equal to current budgeted levels. More optimal model alternatives should be budgeted incrementally, allowing for both actual operational measurements and the maturing of organizational responses to the new policy.

APPENDIX A

COPIES OF READINESS SURVEY CORRESPONDENCE

April 16, 1977

Dear

This letter is a request for you to be an "expert" participant in a thesis program. The purpose of the program is to identify from your personal opinion the most important objectives that have to be accomplised to improve ground forces equipment readiness in the Fleet Marine Forces. The total process will require about one hour of your time during the next six to seven weeks. If circumstances will not permit you to participate during this time frame, please return the enclosed sheet.

The approach we will be using to generate our goals is the Delphi method. The method is oriented toward a controlled and rational exchange of iterated opinions among experts, leading toward an optimal convergence of opinion. This technique is also intended to help explore the problem, leading to greater insight on the problem. The value of the technique rests with the superiority of group opinion over individual opinion and the superiority of private opinion, without pressure to conform, over face-to face opinion.

The process will proceed as follows:

a. Today you are requested to list and scale on the enclosed sheet the specific objectives which, in your opinion, should be accomplished to improve

ground forces equipment readiness in the FMF. Return the sheet today in the enclosed envelope. Keep a complete copy for your reference during later phases.

b. These initial independent opinions of objectives will be grouped into goals and a list based on all participants' objectives will be returned to you with some statistical analysis of the goals for your re-evaluation.

c. The Delphi allows each expert participant to review the conclusions of contemporary experts and statistical data, then considering these to rank the goals. Again, return the list the same day for re-analysis while keeping a copy for later reference.

d. Re-analyzed lists of goals and the new statistics will again be provided for you to rank one last time. You may add any explanatory notes you feel are needed for fuller understanding.

e. These resultant lists will be analyzed a final time for use in a thesis relating to equipment readiness. The final analysis will also be provided for your information.

Although the process may seem long, your repeated reviews of the lists should be relatively quick. The timeliness of your replies will both expedite the process and enhance its continuity for all participants.

Respectfully,

Major W. H. Westhoff

1. Check if you are not able to participate.

2. List the three objectives that in your opinion must be accomplished to improve ground forces equipment readiness. After each short objective statement, rate on the scale your opinion of the objective's value toward improving equipment readiness. 0 - low, 9 - high.

a.

Circle one value: 0 1 2 3 4 5 6 7 8 9

b.

Circle one value: 0 1 2 3 4 5 6 7 8 9

c.

Circle one value: 0 1 2 3 4 5 6 7 8 9

3. Correct mailing address to be used for subsequent correspondence:

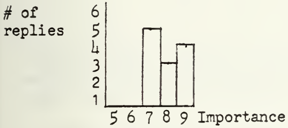
May 4, 1977

Dear

I would like to thank you for your participation in this Delphi analysis. The results so far have been excellent. We produced a total of 21 separate ideas for improving ground force equipment readiness. We generated these from a sample base of officers with outstanting operational and staff experience. The group consists of two general officers, nine colonels, 7 lieutenant colonels, 7 majors and 4 captains.

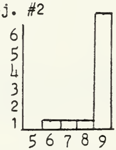
The initial analysis performed on your ideas resulted in the enclosed list of the top ten objectives. Both the frequency and the weight of importance were considered in selecting the list. For your information the following is an overview of the top ten on the list.

Objective #1



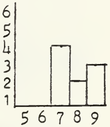
mean = 7.9
std.dev. = .9

Obj. #2



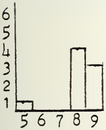
mean = 8.4
std.dev.= 1.1

Obj. #3



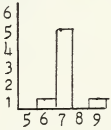
mean = 7.9
std.dev.= .9

Obj. #4



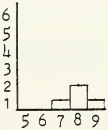
mean = 8
std.dev.= 1.3

Obj. #5



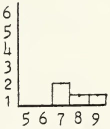
mean = 7.1
std. dev.= .9

Obj. #6



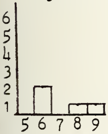
mean = 8
std.dev.= .8

Obj. #7



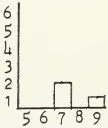
mean = 7.75
std.dev.= 1

Obj. #8



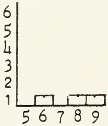
mean = 7.3
std.dev.= 1.5

Obj. #9



mean = 7.7
std.dev.= 1.2

Obj. #10



mean 7.7
std.dev.= 1.5

The purpose of Phase II is to obtain rankings from the panel of the relative importance of each objective. You may want to reconsider your original ideas in relation to the enclosed objective listing. You may rank all or just those objectives you feel confident enough to judge. Your ranking may include ties; however, you must not skip any ranking number within the range you use. An example ranking is:

Rank	Objective numbers
1	4, 7
2	9
3	3
4	2, 5
5	6
6	10
7	
8	
9	
10	

Note objectives 1 and 8 were not ranked; 4 and 7, 2 and 5 were ties; finally, ranks 1 through 6 were used without a skip. Use one of the enclosed sheets for ranking and return it. Complete and retain the extra sheet for your reference in Phase III.

Upon the timely receipt of your ranking, we shall process all the rankings to develop a scaled position listing of the objectives. Phase III will provide you this data and a final opportunity at revising those scaled positions. Again, the timeliness of your reply has importance to the overall analysis.

Respectfully,

William H. Westhoff
Major USMC

Obj. No.	Description
1	Increase and improve occupational/MOS training for maintenance and supply personnel. Included are: a) teach mechanics how to analyze problems b) teach the skills necessary for performance c) teach managerial skills to supervisors
2	Increase command interest in materiel and maintenance management programs. Included are: a) developing dedicated personal involvement b) optimal integration of supply and maintenance resources in a command c) increased awareness of first and second echelon responsibilities
3	Increase the effective use of supply and maintenance personnel. Included are: a) maintain minimum 50% manning level b) require 75% of personnel's time be used for supply and maintenance activities c) match equipment maintenance requirements with availability of personnel d) enhance operator pride in equipment
4	Revise the stockage criteria for repair parts to improve the demand fill rate. Included are: a) consideration for end item application b) availability at first part source greater than 75% c) use of economic order quantities
5	Increase use of all materiel assets in support of maintenance. Included are: a) use of mountout for hi pri NORS b) greater use of ORF assets and R and E program c) use of a peacetime loan pool to reduce equipment turbulence in loaning units
6	Increase the use of maintenance engineering analysis to improve poor performance parts. Included are: a) use of "reverse engineering" b) use of more accurate replace versus repair criteria
7	Increase the effective use of equipment. Included are: a) limit equipment use to field operations, deployment and training b) store non-used T/E in a MCLSB maintenance program

Obj. No.	Description
8	Increase supply system responsiveness. Included are: a) more correct and timely requisitioning b) more intensive SMU management of accounts and items c) centralized repair part support at FSSG
9	Better match of funding with requirements. Included are: a) adequate funding for stockage criteria b) units funded to cover repairs
10	Improve equipment specifications and acceptance test in the acquisition process. Included are: a) emphasis on maintainability b) emphasis on supportability

Ranking Sheet

Rank	Objective Numbers
1	______________________
2	______________________
3	______________________
4	______________________
5	______________________
6	______________________
7	______________________
8	______________________
9	______________________
10	______________________

Note: You do not have to rank all objectives nor use all the ranks. Ties are allowed. Do not skip any ranks within the range you use.

June 7, 1977

Dear

The response and effort on your part has been excellent. The results are both interesting and useful. They demonstrate that this ranking technique could be used to good advantage in the areas such as improving equipment readiness in which value judgments made by individuals are a major source of data. In the following analysis we have a composite judgment that reflects the contribution of each expert according to the proportionate number of judgments he made. While the results are not clear-cut, they do resolve some of the grayness of the area, thereby aiding in decision-making that changes the organization.

The following is a win-loss matrix of the item numbers from our list. Reading across a row horizontally we have the number of times the row item won or was considered more important when compared by the experts to each of the column items. Reading a column vertically we have the number of times the column item lost or was considered less important when it was compared to the row items.

WIN/LOSS MATRIX

Column Items

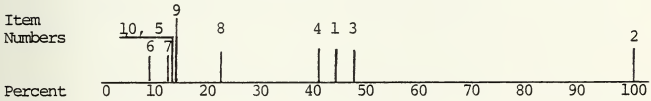
		(2)	(1)	(3)	(7)	(10)	(9)	(4)	(8)	(5)	(6)	Sum (Wins)
	(2)	0	14	16	21	19	20	12	17	19	18	155
	(1)	6	0	10	18	19	15	11	15	17	18	129
Row	(3)	5	8	0	19	17	15	12	17	17	15	125
Items	(7)	1	4	3	0	13	10	7	8	6	10	62
	(10)	4	5	5	10	0	13	8	7	9	9	70
	(9)	1	9	8	12	10	0	6	9	11	10	76
	(4)	9	11	10	14	13	16	0	11	18	14	116
	(8)	4	7	5	13	14	7	6	0	15	14	85
	(5)	3	7	4	13	13	12	5	6	0	12	75
	(6)	3	3	3	7	7	10	4	6	9	0	52
Sum (Losses)		36	68	64	127	125	118	71	96	121	120	946

The following is a listing of the percent of times that each item won in all of its comparisons with other items.

Item	Percent Won
2	81.3
3	66.1
1	65.5
4	52.0
8	47.0
9	39.2
5	38.3
10	35.9
7	32.8
6	30.2

Scaling your ranking preferences resulted in the interval scale shown in the chart below. The top entry is equal to 100 percent and others are scaled with respect to it. The spacing shows the experts' composite preference of each of the items.

Preference Chart



Please rank again the items on the listing. You should consider your prior rankings, the composite ranking data from all other participants and your continuing opinion. Mark your rankings on the enclosed sheet and return it as soon as possible. Keep a copy for your own future reference. A reminder of the ranking rules are on the response sheet.

Respectfully,

William H. Westhoff
Major USMC

Ranking Sheet 2

Rank	Objective Numbers
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Note: You do not have to rank all objectives nor use all the ranks. Ties are allowed. Do not skip any ranks within the range you use.

September 12, 1977

Dear

This is the last letter of our series on the survey identifying areas needing improvement for the upgrading of equipment readiness. I want to thank you for your participation in the survey. For your information some of the results of the survey are summarized below. The results, although not definitive, are useful in hgihlighting those facets of equipment readiness management which should be receiving priority consideration.

A quick recap of our April-to-July survey starts with the phase one nomination of objectives to be improved, followed by the phase two ranking of the ten most popular objectives and, finally, after having seen the first consensus, a delphi phase provided the final ranking of the ojbectives. Enclosure 1 is a phase two and three preference chart which demonstrates the convergence of agreement on the top areas of interest.

The survey results tend to emphasize a primary thrust of goals centered on improving the "people" component of our logistic system, command interest, MOS training and effective use of personnel. The second thrust was toward improved logistic system procedures such as stockage criteria and system responsiveness. Enclosure 2 is a matrix which demonstrates that there was increased agreement on the ordering of goals after the delphi phase, both within and between each grouping of officers. The matrix top entry is the correlation coefficient where 1.0000 is a perfect match of goal orderings. The bottom entry (S =) is the significance level where 0.001 means the two goal orderings with the given correlation could have happened one out of a thousand times by mere chance.

The officer groupings were:

All - Generals thru Captains inclusive
G/Col - Generals and Colonels
LTC - Lt. Colonels
Maj/C - Majors and Captains

The numeric suffix of 1 is the first ranking and suffix 2 is the delphi ranking.

Again, your efforts were appreciated and I thank you for your participation.

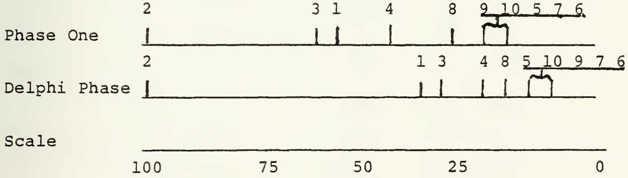
Sincerely,

William H. Westhoff
Major USMC

Comparison of Phase Two and Delphi

Preference Charts

Obj. #	Definition
1	Improved training
2	Command interest
3	Use of personnel
4	Revised stockage criteria
5	Maximize use of materiel assets
6	Improve maintenance engineering analysis
7	Maximize effective use of equipment
8	Supply responsiveness
9	Better funding
10	Improve equipment specifications



Enclosure 1

	All - 1	Gen/Col - 1	Lt. Col - 1	Maj/Cpt - 1
All - 1	C = 1.0000	C = 0.9257	C = 0.8945	C = 0.8321
	S = 0.001	S = 0.001	S = 0.001	S = 0.001
Gen/Col - 1	C = 0.9257	C = 1.000	C = 0.8139	C = 0.6635
	S = 0.001	S = 0.001	S = 0.002	S = 0.018
Lt. Col - 1	C = 0.8945	C = 0.8139	C = 1.0000	C = 0.5474
	S = 0.001	S = 0.018	S = 0.051	S = 0.001
Maj/Cap - 1	C = 0.8321	C = 0.6635	C = 0.5474	C = 1.0000
	S = 0.001	S = 0.018	S = 0.051	S = 0.001

* C = correlation, S = significance

Matrix 1

Phase Two Correlation

	All - 2	Gen/Col - 2	Lt. Col - 2	Maj/Cpt - 2
All - 2	C = 1.0000	C = 0.9837	C = 0.9915	C = 0.9509
	S = 0.001	S = 0.001	S = 0.001	S = 0.001
Gen/Col - 2	C = 0.9837	C = 1.0000	C = 0.9837	C = 0.8825
	S = 0.001	S = 0.001	S = 0.001	S = 0.001
Lt. Col - 2	C = 0.9915	C = 0.9837	C = 1.0000	C = 0.9200
	S = 0.001	S = 0.001	S = 0.001	S = 0.001
Maj/Cpt - 2	C = 0.9509	C = 0.8825	C = 0.9200	C = 1.0000
	S = 0.001	S = 0.001	S = 0.001	S = 0.001

* C = correlation, S = significance

Matrix 2

Phase Three Correlation

Enclosure 2

APPENDIX B

MIMMS DATA BASES

MASTER EQUIPMENT FILE DATA ELEMENTS

<u>Prime Record</u>

ID Number

Equipment Serial Number

Owner Activity Address Code (AAC)

Date of Initial Load

Last Failure Date or Meter Reading

Last Corrective Maintenance (CM) Action Date or Meter Reading

Last Maintenance Action Date or Meter Reading

Total Equipment Operating Time

Materiel Expense for Preventive Maintenance (PM), Life-to-Date

Materiel Expense for CM, Life-to-Date

Total Civilian Labor Expense

Total Military Labor Hours

Number of Failure Actions, Life-to-Date

Sum of Equipment Operating Time Between Failure, Life-to-Date

Number of CM Actions, Life-to-Date

Sum of Equipment Operating Time Between CM

Number of PM Actions, Life-to-Date

Last Quarterly PM Date or Meter Reading

Last Annual PM Date or Meter Reading

Date Last PM

Type Last PM

Prime Record (cont.)

National Stock Number (NSN)

Maintenance Engineering Analysis Code

Equipment Operating Time Code

Major Command Indicator of the Owner

Automated Services Center Code

Active Record Flag

Inactive Date

Modification Control Flag

Number of Trailers

Trailer Record (Up to Nine)

Modification Identification, Number Completed

Date Modification Completed

HISTORY FILE DATA ELEMENTS

Prime Record

Item Identification Number

Serial Number

Date Received in Shop

ERO Number

NSN

Owner AAC

Echelon of Maintenance

Job Identification Code

Quantity Inducted

Cross Reference (X) - ERO-1

X - ERO-2

Priority

Category Code

Deadlined Control Date

Date Closed

Civilian Labor Charge

Parts Charge

Military Labor Hours

EOTC

Meter Reading

Task Data 1

Task Data 2

Task Data 3

Number Unserviceable

ASC Code

Prime Record (cont.)

Number of Trailers

Secondary Reparable Code

Trailer Record

NSN

Document Number of MI

Unit of Issue

Quantity

Date Received

APPENDIX C

SUMMARY OF MIMMS TRANSACTIONS

Transaction Identifier	Explanation of Transaction
0	Adds or changes maintenance information to build the data base for the repair action
T	Transfers selected information from established data base records when equipment is transferred to higher echelons for maintenance
3	Adds non-standard identification data to the records of a repair action
4	Establishes a repair parts used or needed record under a repair action; an alternate use is to record the completion of the modification of an equipment
7	Records the supply status of requisitions
8	Records receipt or cancellation of a repair parts record
9	Closes a repair order and records final maintenance actions taken during repair

APPENDIX D

NAVY'S VARIABLE OPERATING AND SAFETY LEVEL (VOSL) PROGRAM SAFETY LEVEL (SL) COMPUTATIONS

The objective of the VOSL Program is the minimization of requisitions short subject to a funding constraint. The funding constraint in VOSL is the average investment which uses the sum of safety level (SL) and half the operating level (OL) as its definition. In order to compute the SL, the VOSL computes a risk of stockout for each item as:

$$\text{Risk} = \frac{(CF)\ (UP)\ (OL)}{4R}$$

where:

CF = Cost Factor
UP = Unit Price
R = Number of Quarterly Demands

The CF is a function of variable costs and is developed by analysis of the inventory so that the average investment constraint is met. The CF as a factor for the funding constraint acts as a "budget knob" in the computation.

Risk is constrained in that any result less than 0.0100 is raised to 0.0100 and, when the risk computes to more than 0.4999, the SL is made equal to zero. The risk values 0.0100 through 0.4999 are converted to a safety level

factor (SLF) assuming a normal distribution of demands. The following approximation formulas are used:

If $0.0100 \leq \text{Risk} \leq 0.0499$ then $SLF = [1.74 - (11.69)(\text{Risk})]$

If $0.0500 \leq \text{Risk} \leq 0.1399$ then $SLF = [1.4 - (4.68)(\text{Risk})]$

If $0.1400 \leq \text{Risk} \leq 0.4999$ then $SLF = [1.15\ (\text{Risk})^2 - (2.81)(\text{Risk})] + 1.12$

The Safety Level is computed as:

$$SL = (MADD)\ (\sqrt{OST})\ (SLF)$$

where:

MADD = Mean Absolute Deviation of Quarterly Demand

OST = Mean Order Ship Time

The mean OST is forecast quarterly and expressed as months for each item. Only those OST observations that were greater than 10 and less than 120 days are included. The final mean OST is constrained by a maximum of two months.

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